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MAYFLIES OF NORTH CAROLINA

By Jay R. Traver

[Continued*]

Appalachian region.

Almost every stream in this region, in which any collecting was done, yielded one to several species of Ephemerella nymphs. The streams which yielded the largest numbers of species of this genus were the Ocona Lufty River near Cherokee, and the Davidson River in Pisgah National Forest, from each of which six different species of the genus were taken; and Wayah Creek in Jackson Co., near Franklin, with four different species.

Fuscata group

Ephemerella cornutella McD.

This was the commonest species of the mountain region, being found in twenty-three different stations. Extremely variable in coloration, it is nevertheless fairly constant in size, and can be separated from other North Carolina nymphs of the *cornuta* division of this group by the short, blunt tibial spine of the foreleg; the great relative width of the fore femur, which is almost as wide as long; and the relatively short curved frontal horns. It is likewise consistently smaller than either of

* All the plates for this article were published with the first part in the preceding number of this Journal.

the other species of the *cornuta* division taken in this region. Color variations range from light red through darker red to dull olive brown, some being found that were so dark as to appear black.

In the mountains of North Carolina, the species matures from the latter part of June to mid-July. It was collected in the Catawba River and its tributaries; the Swannanoa River and its tributary Flat Creek; Davidson River and two tributaries; Wayah Creek; Pigeon River and three tributaries; Cataloochee Creek near Jarvis Palmer's camp, north of Waynesville; a tributary of the French Broad at Selica; two tributaries of the Cullasaja River south of Franklin; streams entering the Nantahala River; Rocky Broad River at Lecky Gap; Ocona Lufty River; South Toe River; a branch of Laurel River, south of Hot Springs; and in Collins Creek, above Smokemont.

Dr. McDunnough verified my identification of this species.

Ephemerella cornuta Morgan—variety A.

Another member of the *cornuta* division, larger than *E. cornutella* and about the size of *E. longicornis*, n.sp., which is described next, and which it most resembles. Comparison of this species with the latter, however, shows that the frontal horns of *E. cornuta* are not as long and are more curved; that the tibial spine of the foreleg is slightly shorter and does not curve outward so definitely at the tip; and that the hind margin of the fore femur is somewhat more rounded.

The nymph corresponds almost exactly with Miss Morgan's original material on this species, but the imagoes differ slightly, hence I am calling the southern form *variety* A. In my specimens, the foreleg of the female, and of the male except the tarsus and in some specimens the femur, are reddish brown. The tails of both sexes are purplish to purplish brown.

Nymphs of this species were taken from the Catawba River, above Old Fort; Flat Creek; a tributary of the Rocky Broad, at Bat Cave; Cedar Creek, near Glenville; the Ocona Lufty River; one tributary of the Pigeon River at Waynesville, and another near Hazelwood; and in the Little River near the town of Cedar Mt. Several imagoes were reared. They emerged from mid-June to mid-July.

Ephemerella longicornis, sp. nov.

A member of the *fuscata* group. Quite close to *E. cornuta*. Imago with postero-lateral spines on segments 8 and 9, the latter slightly

MEASUREMENTS IN MM.

	BODY	TAILS	FOREWING	FORELEG
Male nymph (4 specimens)	8–9	5–6		
Female nymph (6 specimens)	9–10	5½–7		
Male subimago (2 specimens)	7–8	10	8–8½	5
Female imago (1 specimen)	9	Broken	9	5½

longer. Indentation at apex of penes deeper than in *E. cornuta*. Tails dark purplish brown. Nymph distinguished from *E. cornuta* by 1) the very long tibial spine of the foreleg, which turns outward sharply in its distal half; 2) the longer and straighter frontal horns; 3) the sharper tubercle below the median ocellus; and 4) the straighter hind margin of the fore femur.

Male (*subimago from which the exuvia has been artificially removed*)

Head—Median carina, a transverse band between the bases of the antennae, and antenna, brown.

Thorax—Pronotum olive brown, margined with greyish white. Median line narrowly white. A round white spot on each side of median line posterior to center. Elsewhere, the median line is margined with dark brown. Irregular dark transverse lines on each side. Mesonotum olive brown mottled with yellowish. Median line dark in central portion. Metanotum and borders of mesonotal spine dark brown. Anterior to wing roots, a grey-lavender streak. Pleura olive brown and cream-color. Sternites and antecoxal pieces dark brown; intersegmental areas cream-colored. Axillary cords of fore wing produced into spinous processes on each side of mesonotal spine.

Legs—(subimago) Fore femur yellowish brown, margined and shaded distally with dark brown. Tibia and tarsus dark brown except last tarsal joint and claw, which are lighter brown. Femur and tibia of second and third legs yellow, margined narrowly with brown. First three tarsal joints dark brown; last joint and claw lighter brown.

Wings—Hyaline, brownish at base. Costal margin of fore wing brown in basal half. Longitudinal and a few cross veins of fore wing yellowish brown. Cross veins of stigmatic area anastomosed. Cu_2 and 1st anal not fused at base.

Abdomen—Spines on postero-lateral angles of segments 8 and 9, that on 9 being the longer. Tergites dark reddish brown; 1 lighter in central

portion. Each tergite has a cream-colored triangular patch on each side of the median line, its base on the anterior margin. Tergites darker brown posteriorly and next to the greyish white pleural fold. In this dark margin an irregularly crescentic light mark. Ventrally, yellowish. Sternite 1 brown; 2–4 shaded with grey or lavender. On each a brownish lavender bar parallel and near to the posterior margin. A purplish brown longitudinal streak on each, bordering the whitish pleural fold. Two oblique white marks, one on each side of median line at anterior margin; small whitish dot ringed about with brown on each side of median line, posterior to the center.

Genitalia as on Pl. 9, Fig. 22.

Tails—Dark reddish brown.

Female imago

Differs from male as follows.

Head—Light yellow-brown. Median carina purplish. Antenna light lavender. Two yellow crescentic marks on occiput, near median line.

Thorax—Prothorax yellowish brown, marked with purplish. Median line dark. A large pear-shaped yellow spot on each side of median line near center, each outlined in lavender. A V-shaped lavender area at anterior border, on median line. Posterior and lateral margins shaded with lavender. Mesonotum, metanotum and pleura yellowish brown; intersegmental area cream-colored. Prosternum olive brown. Mesosternum cream-colored anteriorly and on median line; two large lateral areas and antecoxal pieces of second leg chestnut brown.

Legs—Foreleg brown; femur tinged with olive, tibia and tarsus purplish. Other legs yellowish white, tibia and tarsus tinged with brownish lavender.

Abdomen—Eggs dark purplish brown, imparting this color to abdomen. Pleural folds light grey, also posterior margins of tergites. Tergites 9 and 10 dark chestnut brown. Ventrally, posterior margins light grey, wider than on tergites. Sternites 1 and 2, median area of 3, 4 and 7, and all of 8 and 9, washed with chestnut brown. Sternite 8 marked with purple at opening of egg valve. Median line of all sternites light grey. No marks as in male. Postero-lateral spine on 8 turns out at tip more definitely than in male. Apical margin of extension of 9th sternite as on Pl. 9, Fig. 25d.

Tails—Dark purplish brown.

Nymph

A large nymph, light reddish in color.

Head—No occipital tubercles. Frontal horns very long, almost straight. (See Pl. 9, Fig. 14). Sharp tubercle below median ocellus. Frontal shelf fringed with long white hairs Mouth-parts very similar to *E. cornuta.*

Thorax—In most specimens which are not completely matured, the dorsum of the thorax is definitely checkered with light and dark areas, these being very evident on the pronotum and parts of the mesonotum. Fully mature nymphs may not show these areas.

Legs—Fore femur with prominent spines on fore margin, the hind margin almost straight. Tibial spine very long, extending beyond the middle of the tarsus, and in its distal half turning sharply outward. See Pl. 9, Fig. 10. Legs yellowish, with indistinct reddish bands. Two such bands on femur, one on tibia.

Abdomen—No dorsal abdominal spines. Postero-lateral spines of abdominal segments somewhat longer than in *E. cornuta.* Abdomen sometimes lighter in color than head and thorax, but if so, each tergite is darker on posterior margin. Ventrally yellow. A row of dark marks on each side, parallel to lateral margin. Sternites 2–8 hairy, especially along lateral margins. Hairs fine but fairly long, light grey. Gills greyed lavender.

Tails—Yellow to yellowish brown, often becoming purplish brown in fully mature nymphs. In most specimens, each tail has a single dark reddish ring a short distance from the base.

Holotype—Female imago. Reared. Cedar Creek, near Glenville, N. C., July 14, 1930. No. 1095.1 in C. U. collection.

Allotype—Male subimago. Reared. Same locality, July 25, 1930. No. 1095.2 in C. U. collection.

Paratypes—2 male subimagoes, 4 female subimagoes, 30 nymphs. Cedar Creek, July 1929 and July 1930. No. 1095.2–38 in C. U. collection.

The nymphs of this species of the *cornuta* group were less common than either *E. cornuta* or *E. cornutella.* In life they possess a definite checkerboard pattern of light and dark markings on the dorsum of the thorax, with a considerable variation of ground color. They were found on the sides or near the tops of large rocks in the swiftest current, often clinging to the small crevices and irregularities of the rock surface. They

did not move for some time, when the rock was lifted from the water. From my field notes I quote the following;—I found many different shades, colors and patterns (of these nymphs),—it seemed, colored to match the rocks they were on,—but there may have been but two species.—This proved to be true, as both *E. longicornis* and *E. cornuta* were taken from Cedar Creek, where these observations were made. The nymphs were found only at Cedar Creek, which is tributary to the Tuckaseegee River, and in a small stream on Cowee Mt., tributary to the same river. Subimagoes emerged from the 12th to the 25th of July.

Although several subimagoes of both sexes were reared, very few of them were successful in their final transformation. However, several of the males were sufficiently mature to enable me to remove the subimaginal skin for purposes of study.

Ephemerella conestee, sp. nov.

MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Male nymph (4 specimens)	5½–6	2–2½		
Female nymph (7 specimens)	5–7	2¼–4		
Male subimago (1 specimen)	6	3	7	4
Female imago (1 specimen)	6¼	Broken	7¼	3

This species belongs in the *fuscata* group. It is a late-maturing form, imagoes appearing the last week in July. Male adult with orange to rose-tinged abdomen. Body and legs marked with purplish rose. Genitalia of the *fuscata* type. Wings tinged at base with purplish brown, veins very faintly yellowish. Tails brown, orange-tinged at base.

Nymph with very short frontal horns. Anterior margin of fore femur with spines. Short dorsal abdominal spines present on segments 2–7. Strikingly marked with yellow and brown; quite variable in size and color. Some specimens show distinct rose markings on head, thorax, femora and dorsal apsect of abdomen.

Male (subimago from which exuvia has been removed, to show colors of imago)

Head—Light brown tinged faintly with purplish. Compound eyes yellowish to orange.

Thorax—Pronotum with rather prominent median carina; purplish rose except semicircular dark greyish area at center of anterior border. Mesonotum light olive brown, strongly tinged with lavender, especially at median line and lateral borders. Spine bordered with dark brown, also lavender-tinged. Metanotum brown tinged with purplish rose. Pleura light olive brown, cream colored to whitish at sutures. A rose-colored streak from wing-roots to pronotum, another from wing to base of fore leg. Ventrally darker olive brown.

Legs—Fore femur greyish, streaked with purplish rose. Tibia and tarsus dark olive brown. Other legs very light olive-brown, joinings and claws dark grown.

Wings—Hyaline. veins faintly yellowish. Tinged with purplish brown at base of forewing. Cross veins of stigmatic area anastomosed. Several indistinct cross veins before the bulla.

Abdomen—Tergites 1–3 deep purple, tinged with rose. Tergites 4 and 5 orange marked with bright purplish red; darker on each side of median line, halfway to pleural fold, and at center of pleural fold. Posterior margins narrowly greyish, also postero-lateral angles. Tergites 6–9 similar to 4 and 5, but lighter in color, due to a definite wash of yellow, thus appearing light orange. Ventrally, sternite 1 greyish lavender; 2 and 3 light purplish tinged with rose; 4–6 greyed purplish rose; 7–9 yellow with rose tinge.

Tails—Orange brown at base, shading into smoky olive brown. Joinings slightly darker.

Genitalia—Forceps base orange brown, forceps smoky brown; penes deep rose. *Fuscata* type of genitalia. See Pl. 9, Fig. 5.

Female imago

Differs from the male as follows.

Head—yellow. Antennal sclerite bordered with rose; antenna greyish purple at base, filament grey. Purple spot below each compound eye, between eye and outer margin of antenna.

Thorax—Pronotum yellow; purplish rose markings at center of anterior border; several streaks of same color on lateral margins; narrow smoky markings in central portion. Mesonotum yellow, the median line and borders brown; spine and its margin likewise brown. Pleura light yellow, a faint rose streak anterior to wing roots. Ventrally, prosternum and anterior of mesosternum white, other portions yellow. Metasternum purplish.

Wings—Tinged at base with purplish rose. Costal border of fore wing purplish brown, as also vein M1 (Morgan). Veins Sc and Rs light brown, also other forks of M, and Cu. Other veins colorless or yellowish white.

Legs—Fore femur as in male. Fore tibia purplish grey, darker distally, and margined with purplish rose. Distal two-thirds of first three tarsal joints, and large spot on claw, dark purplish grey; remainder of tarsus white. Other legs yellowish white, claws purplish.

Abdomen—Yellowish white. Segment 10 yellowish brown, tergites 8 and 9 opaque white. Eggs give abdomen a rose-purple tinge. Tergites 1–3 have a dark purplish brown streak next to the pleural fold, and on 2 and 3 a transverse streak below anterior margin, halfway from median line to pleural fold. Apical extension of 9th sternite as on Pl. 9, Fig. 25 c.

Tails—Whitish basally, no dark joinings. Distal portion missing from specimen.

Nymph

Head—Very short blunt frontal horns, not extending beyond second antennal joint. Pair of short, conical tubercles on occiput, and two shorter pairs anterior to these, on vertex, tending to be slightly more prominent in female nymph. Clypeus fringed with white hairs. Slight prominence over each ocellus. Two basal segments of antenna dark brown, remainder yellowish. Compound eyes black in center with amber outer rims. Head brown, mottled with yellow and darker brown, this being most prominent on vertex and occiput. For appearance of head, see Pl. 9, Fig. 8.

Thorax—Pronotum wide; slightly wider at anterior margin, its lateral margin incised slightly in its posterior half. Yellow, irregularly mottled and bordered with dark brown. No tubercles, but irregularities in surface on each side of median line. Usually two dark dots on each side of median line, near posterior border. Mesonotum yellow to yellowish brown, streaked longitudinally with brown bars in anterior half and before wing roots. On anterior margin on each side, two dark brown dashes near lateral border, and lateral border itself dark brown. Tips of wing-buds dark brown.

Legs—Yellowish to light yellowish brown, banded indistinctly with brown and bordered with dark brown. Two dark bands on each femur, as well as a dark bar at each end. Fore femur with spines on anterior margin. See Pl. 9, Fig. 17. Short brown tubercles on upper surface

of each femur. Tibiae margined but not barred with dark brown, except some young specimens, which have a brown bar near the distal end. Tarsi with brown bar near basal end. Claw shown on Pl. 9, Fig. 16.

Abdomen—Dorsal spines present on 2–7; very short on 2, increasing slightly in length posteriorly. Tergites 1–4 brown, mottled with yellowish white on lateral borders. Tergites 5 and 6 yellow; 7 and 8 yellow mottled with brown; 9 and 10 dark brown. This description applies to a specimen intermediate in color, neither the lightest nor the darkest collected. In light forms, tergites 5–8 are yellow, and 2–4 are yellowish brown marked with brown. Some specimens show distinct rose shadings on the dorsum of the abdomen. In all forms, segments 3–9 with short postero-lateral spines; shortest on 3. Ventrally, yellowish shading into yellowish brown posteriorly. Sternite 9 dark brown.

Gills purplish, a large whitish oval area in the anterior portion. Gills present on 3–7, not operculate on 3.

Tails—Amber yellow to yellowish brown, becoming brown in distal fourth. Crossed by four to seven narrow bands of white.

Holotype—Male subimago. Reared. Tributary of Pigeon River, N. C., near Hazelwood, August 2, 1930. No. 1096.1 in C. U. collection.

Allotype—Female imago. Reared. Same location, July 30, 1930. No. 1096.2 in C. U. collection.

Paratypes—8 nymphs. Same location, July 20, 1930. No. 1096.3–10 in C. U. collection.

The nymphs of this species were among the most abundant in the genus Ephemerella, in the Appalachian region. Immature nymphs were taken at many stations during June and July, the mature forms appearing only during the latter part of July. Only two nymphs were successfully reared, both of these being from a small tributary of the Pigeon River about four miles west of Hazelwood, in Haywood Co. Had it been possible for me to remain longer in the mountains, it is quite probable that others could have been reared. This species is the last to reach maturity of any of the Ephemerellas collected.

Stations and dates of collection of this species are as follows. A small tributary of the Tuckaseegee River, on Cowee Mt., first taken June 28, 1929, and others at later dates; several small tributaries of the Nantahala River, including Hyde Mill Creek east of Robbinsville, on June 29, 1929; Cedar Creek, a tributary of the Tuckaseegee, near Glenville, June 30

and later dates; a small tributary of the Cullasaja River, eight miles south of Franklin, July 1, 1929; Wayah Creek at the base of Wayah Mt., in Jackson Co., July 1, 1929, and several later dates; Mingus Mill Creek, a tributary of the Ocona Lufty River, July 12, 1929; three small tributaries of the Pigeon River, one of them Allen's Creek, all near Waynesville and Hazelwood, on July 15, 1929, and succeeding dates; a small tributary of the North Fork of the Swannanoa River near Swannanoa, June 15, 1930; Rock Creek, tributary to the French Broad River, near Rosman, July 10, 1930; and Conestee Creek (for which the species is named), a tributary of the Little River, July 12, 1930.

Ephemerella wayah, sp. nov.

MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Male nymph (2 specimens)	6	2½–3		
Female nymph (7 specimens)	6–7	2–3½		
Female subimago (1 specimen)	6½	4	7½	3

A species of the *fuscata* group. Nymph much flattened, hairy, with spines on the front margin of the fore femur, very short frontal horns, antennae set in notches on each side of a broad frontal shelf, and abdomen very hairy ventrally. In life, grey-green in color, becoming brownish yellow in alcohol. Color descriptions from alcoholic specimens.

Nymph

Head—Clypeus carved out at each side, the antennae fitting into these notches. Genae very well-developed; projecting forward and outward bluntly to form one side of the notch receiving the antennae. Short inconspicuous frontal horns present. No occipital tubercles. Lateral ocelli larger than median ocellus. Conspicuous fringe of long hairs bordering genae and clypeus. Head yellowish brown. Antenna dark brown at base, remainder light brown. Dark brown mark at center of clypeus. Antennal sclerite and frontal horn also dark brown. A dark spot on each side of vertex behind each lateral ocellus, and another on each side of occiput, at margin of eye. Head and mouthparts shown on Pl. 9, Figs. 2, 6, 7, 9, 12, 13 and 20.

Thorax—No tubercles. Pronotum slightly wider posteriorly, the anterior margin almost imperceptibly incised. Yellowish brown, marked

irregularly with darker brown. Mesonotum same color, likewise marked with dark brown. Marks are: in anterior half, a wedge-shaped area on the median line; a streak on each side of the median line, anterior to the wing roots. Tips of wing buds dark brown. Finely hairy throughout. Yellowish ventrally.

Legs—Femora much flattened; fore femur with teeth or spines on front margin. Tubercles on dorsal surface of all femora, and many long hairs on each margin, particularly in the basal half. Tibial spine short and blunt on foreleg; a blunt projection also at this point on other legs. Femur dark brown at each end, and with a dark bar near each end, usually very indistinct in the central portion. Dark brown bar near base of tibia, and a wider one in the distal half, not reaching the distal end. Basal half of tarsus dark brown. Claws orange brown. See Pl. 9, Figs. 18 and 19.

Abdomen—Tergites yellowish to light olive brown. A light specimen is yellow dorsally; tergites 2–4 with dark brown transverse bar on each side between median line and pleural fold. Lighter brown bars similarly placed on 5–7; a narrow dark brown median line. A dark form is olive-brown dorsally, tergites 8–10 washed with yellow. An intermediate form is olive-brown on tergites 1–5; 6 and 7 yellowish brown, the lateral margins yellow; 8–10 yellow. All color forms have the spinous extensions of the abdomen dark brown in the anterior half of the outer margin; postero-lateral spine white at tip; and a small black mark above each pair of gills. Abdomen very hairy dorsally.

Ventrally, yellow. A line of dark marks on each side, between median line and pleural fold; on sternites 1–3 these marks are round, on 4–9 elongate. On dark forms, anterior borders of 1–4 are dark brown except at center; a dark oblique mark is present on each side of 5–8; 9 is light brown except at center of posterior border. All color forms have venter very hairy on entire surface of 9, and lateral margins of 3–8, thus forming a partial 'adhesive disc' of the type so well developed in *E. doddsi*. In *E. wayah*, however, there are no hairs across the abdomen anteriorly.

Gills present on 3–7. Light purplish grey, whitish oval region near center.

Tails—Dark brown at base, then banded alternately with yellow and dark brown, each color band being 2 to 3 segments in width.

Female subimago

Head greyish white. Base of antenna greyish white, filament brown.

Thorax—Pronotum olive brown with ruddy shadings. Rather pro-

nounced carina on median line. A small rounded grey blotch at center of sclerite, on median line; another on each side of median carina, anterior to the central mark. At posterior border on each side, a large somewhat dumb-bell-shaped mark occupying most of the border. Mesonotum greyish white marked with olive to chestnut brown in anterior portion; on each side of central area opposite wing roots; and on lateral borders of mesonotal spine. Pleura greyish white with faint brown markings. Ventrally greyish white.

Legs—Yellowish white. Fore leg margined and faintly streaked on femur with olive-brown. Claw and all joinings darker brown.

Wings—Smoky olive brown.

Abdomen—Lateral margins somewhat flaring; 8 and 9 with very short backward-projecting spines. Greyish white; eggs impart a purplish brown color. Apical extension of 9th sternite as on Pl. 9, Fig. 25a.

Tails—Purplish brown, greyish white at tip.

A male subimago, only partially transformed from the nymphal stage, shows dark olive-brown abdominal tergites, becoming lighter posteriorly; the flaring lateral margins whitish; a dark median dorsal line. Ventrally, very light olive brown, marked with dark brown lateral lines and oblique bars on each sternite.

Notes on this species

The nymph is rather similar to that of *E. fuscata*, but differs in these respects: 1) spines on fore margin of femur are more numerous and more prominent; 2) tibial spine of fore leg longer; 3) femur of second and third legs not as wide, lacking the prominent backward extension present on *E. fuscata;* 4) body and legs more hairy; 5) slightly smaller in size;—body 6–7 mm., that of *E. fuscata* 6½–8 mm.; 6) genae not quite as prominent.

Holotype—Female nymph. Wayah Creek, near Franklin, N. C., July 1, 1929. No. 1097.1 in C. U. collection.

Paratypes—Female subimago. Allen's Creek, N. C., July 15, 1929. Male subimago, 9 nymphs. Wayah Creek, July 1, 1929. No. 1097.2–12 in C. U. collection.

This interesting grey-green flattened nymph was found at two stations only. It was first collected from Wayah Creek near Franklin, on July 2, 1929, and named for this delightful little stream which arises on Wayah Mt. (This, as well as many other euphonious geographic

names of western North Carolina, is of Cherokee Indian derivation. Wayah is said to mean 'wolf.') A considerable number of nymphs were taken from this same stream on July 8, but all were destroyed in a flood which washed away the rearing cages in which they had been placed. No others could be obtained that summer.

What appear to be nymphs of the same species were taken on July 15, 1929, from Allen's Creek near Hazelwood, and from these one female subimago was obtained. Wayah Creek was visited again on July 27, 1930, at which time but one of the grey-green nymphs was obtained. It was not reared.

These nymphs were found on the upper surfaces or sides of rather small rocks in the main current, these rocks being overgrown with small algae and diatoms. The nymphs themselves, being hairy, were also thickly covered with ooze and diatoms. As they did not move for some time after the rock was lifted from the water, they were very difficult to locate. I quote from my field notes: 'I notice that the flat grey-green Ephemerellas sit with their backs (thoracic region) humped up, and often cling to the side of rocks in swift water, much as *E. doddsi* is described as behaving!'—The nymphs clung so tightly to the rock that it was difficult to remove them without danger of injury. The semi-disc of hairs on the ventral surface of the abdomen, much less developed than in *E. doddsi*, but apparently the same sort of device for clinging, would seem to account for this ability to hold to the rock.

Ephemerella tuberculata Morgan

Nymphs of this species were taken from Cedar Creek on June 30 and July 21, 1929, and on July 23, 1930; from the Ocona Lufty River near Cherokee on June 22 and July 28, 1930; a tributary of the Swannanoa River, July 8, 1930; and from Conestee Creek on July 12, 1930. Several imagoes were reared from these nymphs emerging from the middle to the end of July.

Nymphs of *E. tuberculata* were found on the sides or upper surfaces of large stones, often those which were much overgrown with water mosses, sometimes in company with *E. longicornis*, or in other localities along with nymphs of *E. catawba*. Like these, the nymphs did not move for some time, and could usually not be distinguished from the stone or moss until they did move. In life, some of these nymphs possess a prominent whitish dorsal stripe. They are semi-flattened forms, and tend to cling tightly to the rock, but may be quite readily removed without injury. Genitalia shown on Pl. 9, Fig. 27.

Ephemerella lata Morgan

Nymphs were found in Davidson River June 19, 1929, and at several later dates during June and July of 1929 and 1930. Imagoes were reared from nymphs collected here in 1930, emerging from July 19 to 24. Two nymphs were found also in Flat Creek in June 1929, but were not reared.

They were sometimes found in company with nymphs of *E. cornutella*, and like this species were obtained by hand-picking. Small stones in rapid water seemed to be preferred by them in Davidson River, where many were collected from small stones in the most rapid current, being especially numerous where the water was 1½ to 2 feet in depth. Genitalia shown on Pl. 9, Fig. 1.

Invaria group

Ephemerella dorothea Needham

Nymphs were taken from Flat Creek, and subimagoes captured as they emerged from the waters of that stream, in the second week of June, 1929.

Ephemerella rotunda Morgan

The only record of the occurrence of this species within the state is found in several nymphs collected by Dr. J. S. Gutsell from Scott's Creek and its Monteith branch, near Sylva, on April 8, 1930.

Ephemerella catawba Traver

From nymphs taken from the Catawba River on June 20, 1929, a male emerged on the following day. Other nymphs, from which no imagoes were reared, were taken from the following stations. Dr. J. S. Gutsell collected several from Scott's Creek near Sylva on April 8, 1930. Prof. Needham found these nymphs near Highlands on April 7, 1929, and near Chimney Rock on April 8, 1929. My collections are: Ivy River, June 15, 1929; Bottomless Pools near Chimney Rock, June 17, 1929; small stream on Cowee Mt., June 28, 1929; Davidson River, June 20, 1930; Ocona Lufty River, June 22 and July 28, 1930; Laurel River near Hot Springs, June 29, 1930; Rock Creek, July 10, 1930; and Conestee Creek, July 11, 1930.

My original supposition that two species were represented in this

material seems not to be justified. Differences in size and coloration among the nymphs are not supported by structural differences. Large and small forms are similar in habits and habitat, as well as in shape, but vary considerably in color, as already noted. They were usually obtained from moss-covered stones in the swift current. If such a stone be lifted from the water, in five minutes or more these nymphs begin to push their way from among the roots and stems of the moss, and then for the first time become visible. Their characteristic attitude is to hold the tail erect over the back. In life, they blend quite perfectly with their environment.

Simplex group

Ephemerella sp.? No. 1 (near *E. simplex*)

Small flattened nymphs, with fore femora much expanded and 'saw-tooth' lateral extensions of the abdomen, were found in the small stream on Cowee Mt., in the Ocona Lufty River, and in Little River near the town of Cedar Mt., during the latter part of June and early July. A female measured 6 mm. in length, a male 5 mm. These nymphs are quite similar to those of *E. simplex*, but differ in these respects: 1) the body is slight, narrower than in *E. simplex*; 2) posterior edges of the postero-lateral spines are more sharply curved; 3) light reddish brown in color; fore femur slightly wider; 4) distal joint of labial palp somewhat shorter; and 5) central portion of hypopharynx narrower.

Others not included in groups

Ephemerella deficiens Morgan

Nymphs were taken from the North Fork of the Swannanoa River; Little River near Cedar Mt.; Ocona Lufty River; Davidson River and a tributary; and from Bald Creek. From the latter stream the subimagoes were emerging on July 6, 1930, the day on which the nymphs were taken. Both here and in the Ocona Lufty River, these nymphs were found among the moss and other plant growth which thickly covered the tops of all the larger rocks, and they could be seen only after the rock had been left out of water for some minutes, when they began to scramble about. Nymphs of *Isonychia notata*, *Ephemerella catawba*, a species of Baetis, nymphs of large stoneflies and larvae of the caddisfly Hydropsyche were also numerous in this alga association.

Ephemerella sp? No. 2

This species of very small nymph was found in a tributary of the Pigeon River at Waynesville; at the Bottomless Pools, near Chimney Rock; in Davidson River; and in Wayah Creek. It was taken during the latter part of June and early July. No imagoes were obtained. A short description of this nymph follows.

Size—Body of male nymph, $3\frac{1}{4}$ mm; of female, $3–3\frac{1}{2}$ mm. Tails of male nymph, $1\frac{1}{4}$ mm.; of female, $1–1\frac{1}{2}$ mm.

Body cylindric. Occipital and prothoracic tubercles present, likewise dorsal abdominal spines. Lateral margins of abdominal segments prolonged somewhat into flattened processes, with many rather prominent spines on the outer margins. Postero-lateral spines short except on 9, on which the spine is very prominent. Femora somewhat flattened. Gills present on 3–7. Dark olive-brown, mottled with yellowish white. Short maxillary palp.

Head—Antenna white basally, remainder light brown.

Thorax—Pronotum widely white on each lateral border, and a small whitish area at center of posterior margin. Mesonotum mottled brown and yellowish.

Legs—Yellow with dark brown bars. Wide bar at base of femur, enclosing a small yellow spot; narrower dark band at distal end. Basal half of tibia dark brown, likewise all of tarsus except a yellowish streak near the distal end.

Abdomen—Tergites 4–6 whitish in center, between the gills; 10 all whitish yellow. Gills smoky grey. Ventrally, dark olive brown, no definite markings. Tails blackish brown basally, then yellowish white, crossed by a blackish band a short distance from the tip.

GENUS SIPHLONURUS Etn. 1868

Siphlonurus mirus Etn.

The black-masked nymphs of this species were collected from the lake near Liberty in the spring of 1929 and again in 1930. From these several imagoes were reared successfully, establishing the identity of the species. Nymphs were taken in 1929 on March 24 and again on April 23. In 1930 the first of these were collected on Feb. 18, and a few more on March 16. The time required for one female to complete its subimago stage was 36–40 hours; it emerged on the afternoon of Apl. 13. A male which emerged the afternoon of Apl. 16 required $51\frac{1}{2}–53\frac{1}{2}$ hours to complete its transformation. Mature nymphs of this species were also taken at Highlands, N. C., on April 4, 1929, by Prof. J. A. Needham.

Siphlonurus quebecensis Prov.

Nymphs of this species were quite abundant in the lake near Liberty and in Hamburg Lake. From each of these localities numerous nymphs were reared to adults. The subimagoes usually emerged indoors from 8 to 10 a.m., though a few emerged about 3. p.m. At Hamburg Lake they were observed emerging from 3 to 4 p.m. The subimago stage lasted from 47½ to 52½ hours, in nine specimens whose emergence and final transformation were carefully timed. Of these, six required exactly 48 hours. The nymphs were collected from the lake near Liberty on the same dates as those of *S. mirus*, and from Hamburg Lake on Mch. 31 and Apl. 5 in 1929, and Feb. 24 and April 17 in 1930.

Siphlonurus marginatus, sp. nov.

A few nymphs of a different species, collected at the lake near Liberty in the spring of 1929, proved on being reared to be a new species. This is a small form, both nymphs and adults possessing a black mid-ventral line. However, as adults of *S. securifer* McD. and *S. decorus*, n. sp. have similar ventral markings, this character is not in itself sufficient for determination. The tergites of the adults, when viewed from above, appear to be margined laterally and posteriorly with dark brown, hence the specific name.

MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Nymph	9–9½	4–4½		
Male imago (4 specimens)	9–10	12–14	9	7½–9½
Female subimago (1 specimen)	10	9	9	9

Nymph

Head—Light tan with brown marks. Two longitudinal parallel brown bars on vertex and occiput, one on each side median line. Brown spot on subgena. Frons brown except for cream colored band in center and triangle on each anterior angle. Ocelli small. Antennae cream colored. Mouthparts not differing materially from *S. mirus* or *S. quebecensis*.

Thorax—Light tan marked with brown. A brown spot on each side of center, on posterior margin of pronotum; two dark spots in each anterior lateral angle. Few irregular brown marks on meso- and metanotum. Brown mark just above each coxa. Cream-white ventrally.

Legs—Cream colored, femur light tan. Brown spot on each coxa. Foreleg without marks except one dark spot at tibio-tarsal joining. Second and third legs with brown stripe near basal end of femur and another one-third from distal end. Dark spots anteriorly at joints and near basal end of tibia. Tarsus equals $\frac{3}{4}$ of femur; tibia slightly shorter than tarsus.

Abdomen—Light tan dorsally, marked with dark brown. Tergites 2–4 with 4 indistinct marks in posterior angle of pleural extension. One mark in center of pleural extension of tergite 5, two on 6. 7–9 with one long brown streak in this position. In general, the tergites are marked as follows. A dark brown blotch in the posterior lateral angle, becoming a mere line on tergites 7–9. An oblique bar anteriorly on each side of median line, in some tergites not based on the anterior margin; this usually reaches to center of tergite. On outer side of this bar another brown bar, in 7–9 as long as and broader than the one near the median line. Also in tergites 7–9, these bars are connected at their anterior ends by a cross-bar. On tergites 3 and 6, a large irregular brown mark occupies the center of the tergite, in 6 sometimes shaped like a clover leaf. Tergite 10 with only two bars, one on each side of median line, and the posterior lateral angles margined with black. Posterior margins of tergites 1–8 brown except in center and on pleural extensions. 6–10 with dark spot on posterior margin near beginning of pleural extension. Ventrally cream colored, a continuous median black line on sternites 3–9, a short black bar medially on 2. Posterior lateral angles of 10 black; an oblique brown bar on each side of median line.

Gills white, tracheae black. Gills double on 1 and 2 only.

Tails cream colored, ringed narrowly with light brown at joinings. Every third or fourth joining near base has wider brown band. All three tails crossed by black band two-thirds from basal end, a narrower one nearer the tip.

Male imago

Head—Yellowish brown. Compound eyes grey-lavender, contiguous posteriorly. Ocelli white, ringed with purplish brown. Basal joint of antenna cream-white, margined with brown. Filament light brown. Dark brown spot beneath antenna, on each side of median carina. Grey-lavender spot on median carina.

Thorax—Bright yellowish brown, darker on meso- and metathoracic spines, mesosternum and margins of mesonotum. Posterior lateral

angles of prothorax cream-white. Dark brown triangle in center of pronotum. Pleura same, somewhat lighter; sclerites dark brown.

Legs—Foreleg light tan to second tarsal joint, remainder of tarsus greyish white. Joinings dark brown. Indistinct olive-brown area near center of femur. Second and third legs whitish; joinings, claws and distal half of last tarsal joint brown. Indistinct brownish band near distal end of femur. Tarsus almost 3 times length of tibia.

Wings transparent. Apical portion of costal and subcostal cells milky white. Longitudinal veins brown. Cross veins along inner margin of fore wing light brown; most others indistinct whitish or yellowish.

Abdomen—Dorsally olive brown, lighter on venter. Tergites 1–8 with dark posterior margin, somewhat lighter at median line. In posterior lateral angle of each is a dark brown spot, rather oblong. Forward and inward from this runs a narrower dark brown line, attaining the anterior margin halfway between median line and pleural fold. Viewed from above, each tergite thus appears to be bounded by a wide dark brown band. Tracheae indicated by dark lines. A dark bar on each side from anterior margin to center of tergite (in one specimen, not reaching anterior margin). Posterior to these bars, a short transverse band crosses the center of each tergite. Between the dark lateral border and the pleural fold is an olive cloud, becoming cream-white near the anterior margin. Tergites 9 and 10 similar to others, but pattern less distinct.

Sternites 1 and 2 light olive-brown, margined posteriorly with white. 10 dark olive brown; 9 similar, except for white area on each side of center on posterior margin. 3–8 silvery white, with light olive band on each side near pleural fold, extending length of sternite. A very dark brown median stripe extends continuously from the base of 1 to the end of 9, widened in each sternite near the posterior margin. In center of each sternite, a small black dot on each side of this median stripe, quite close to it. Further out from the median stripe and nearer the anterior margin is an oblique brown mark on each side.

Tails yellowish white, joinings dark reddish brown.

Genitalia as on Pl. 11, Figs. 1 and 6.

Male subimago

Quite similar to imago, but head and thorax creamy white except mesonotum, which is yellowish and margined with brown. Abdominal

markings similar, but background of tergites darker. Tails light brown, joinings dark red-brown.

Female subimago

Quite similar to male subimago, with these differences. Abdomen dorsally very light tan, the tergites lacking the dark posterior border, but with the typical brown markings on each side. All legs yellowish white, joinings brown.

Holotype—♂ imago. Lake near Liberty, N. C. Reared from nymph, May 1, 1929. No. 1023.1 in C. U. collection.
Allotype—♀ subimago. Same. No. 1023.2 in C. U. collection.
Paratype—♂ imago. Same. No. 1023.3 in C. U. collection.

The smaller size of this species, the lighter coloring and the very different genitalia serve to separate this species from *S. securifer*, which has similar ventral markings. By both color and structure of genitalia it is distinguished from *S. decorus* n. sp., which will now be described.

Siphlonurus decorus, sp. nov.

On April 11, 1929, Prof. Needham collected Siphlonurus imagoes from Goshen Swamp and Burncoat Swamp in the coastal plain region of the state. Among these are many specimens having prominent purplish-rose markings, the posterior sternites powder-white, and a black mid-ventral line. Comparison of these with the description and figure of the genitalia of *S. securifer* McD., which they most resemble, seems to indicate that the species under consideration is not this. The color of the two species differs considerably, except for the similarity of the dark mid-ventral line. However, this line is present also in *S. marginatus* n. sp. The genitalia bear a general resemblance to the figure given for *S. securifer* by McDunnough, but differ in posessing, in most cases, spines on the ventral lobes of the penes. Moreover the species is smaller than *S. securifer*. The differences seem sufficient to warrant the erection of a new species for this material. The general similarity of the genitalia and the presence of the dark mid-ventral line and its associated markings in the three species *S. securifer* McD., *S. marginatus* n. sp., and the species now under consideration would suggest that these three belong in the same group within the genus.

MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Male imago (7 specimens)	9–10	16½–19	9–10	9–11
Female imago (2 specimens)	9	12½–13	10–10½	4½–5½

Male imago

Head—Dark purplish brown, with white transverse band along lower margin of frons and another just below ocelli. This leaves a purplish band across the face below the antennae, crossing the frontal carina. Compound eyes purplish, basally crossed by two greyish white bands and margined posteriorly with same. Ocelli pearly white, ringed broadly with purplish black at base. Proximal half of basal joint of antenna whitish; remainder brown.

Thorax—Dark olive-brown. Mesonotum light tan along median line in anterior portion, and a lateral similarly colored line on each side of center. Pleura with cream colored markings, superimposed on which are conspicuous patches of purplish rose. Rose patch on each side anterior to meso- and metanotal spines. Whitish transverse bands on pro-, meso- and metasterna; between legs on prosternum, just anterior to legs on other divisions.

Legs—Light brown, darker at joinings. Purplish rose spot on each coxa. Conspicuous brown band on each femur, one-third from distal end. Foreleg generally as long as body. In a few specimens slightly shorter, in others slightly longer. Spines on tibia of foreleg and protuberances on first two tarsal joints very prominent. Tarsal joints of foreleg, in descending order; 3, 1 and 2 (equal), 4, 5. Tarsus almost three times as long as tibia.

Wings—Transparent, except apical portion of cells C and Sc, which are milky. Longitudinal veins of forewing dark purplish brown, also humeral cross-vein. Longitudinal veins of hind wing, and all other cross veins of both wings, brown.

Abdomen—Tergites and first two sternites dark olive-brown with cream colored markings. Tergites 2–6 with anterior half of mid-dorsal line light-colored. On 7–9, a light streak along each side of median line, which is itself dark. A dark brown stripe on each side of this light streak, wider at base. Lateral to this a dark brown triangle, its base on posterior margin, its apex not reaching the anterior margin. Two light triangular areas on each side are thus formed, one between the first stripe

and the apex of the triangle, the second occupying the anterior lateral angle. Tergite 10 dark brown in center, light brown on each side. Ventrally, sternites 3–6 purplish grey, silvery anteriorly and along posterior margins. A dark purple-brown median line extends continuously from posterior margin of 1 to posterior margin of 10, widened at anterior and posterior margins of each sternite. A small black dot appears on each side very close to this line (touching it on sternites 7–9) at the center of the sternite. On each side of the dark stripe and anterior to the center on each side is a larger dark brown somewhat oblong spot. Parallel to the pleural fold on each side is a narrow band of purplish black, not quite reaching the upper and lower margins of each sternite. On sternites 3 and 4, this band is somewhat widened posterior to the center. Sternites 7 and 8, and posterior lateral portions of 9, powder-white except for median stripe and lateral spot and bar.

Genitalia—as on Pl. 11, Figs. 9, 15, 16 and 18. Forceps and forceps base light brown with purplish rose markings. Genitalia somewhat resemble those of *S. securifer*, but differ in details. A certain amount of variation in the penes is observable, principally as to the presence of spines on the inner surface of the ventral lobes. On one specimen no spines are present. In all others examined one, and in one case two spines appear on each side. These show variation in size on different specimens, and even on the two sides of the same specimen.

Tails—Dark brown basally, soon becoming light tan. Joinings dark purplish brown.

Female imago

Very similar to male, with these minor differences. Lateral greyish stripe on each side of mesonotum slightly wider. Anterior sternites flushed with pale pink. Sternites 7–9, on some specimens, lack the powder-white markings. Tails greyish white, joinings as in male. Apical margin of sternite 9 as on Pl. 12, Fig. 18.

Holotype—♂ imago. Goshen Swamp, N. C. Taken in flight by Prof. J. G. Needham, April 11, 1929. No. 1024.1 in Cornell collection.
Allotype—♀ imago. Same data. No. 1024.2 in C. U. collection.
Paratypes—7♂ imagoes, 2♀ imagoes. Same data. No. 1024.3–11 in C. U. collection.

Siphlonurus decorus, light form

Along with the specimens showing the characteristic coloring of *S. decorus* are several others of both sexes, predominantly brownish, but a

few of which show slight indications of rose markings. The powder-white of the posterior sternites is lacking in both sexes. Genitalia are so similar to those of *S. decorus* as to be indistinguishable from them, as are also the relative lengths of the joints of the foreleg. Some are slightly smaller than the purple-marked forms, others are fully as large. The color description of *S. securifer* does not differ widely from these forms, but their smaller size and the presence of spines on the penes would seem to prevent placing them in this species. For the present, therefore, they will be considered as *S. decorus*, light form.

GENUS SIPHLOPLECTON Clemens 1915

Key to Siphloplecton Nymphs

1. Gills double on segments 1–3 2
   Gills single on all segments 4
2. Venter of abdomen with three uninterrupted longitudinal brown lines, one median and the others lateral. Claws of second and third legs almost equal to respective tarsi in length ..... *basalis*
   Venter of abdomen not marked as above. Claws of second and third legs ⅔ to ¾ length of their respective tarsi (i.e., relatively shorter than in *S. basalis*) 3
3. Venter of abdomen with but one longitudinal brown streak along median line ..... *signatum*
   Venter of abdomen with very dark brown median longitudinal streak, and on each side of this near the pleural fold a row of black dots, two on each side of each sternite ..... *speciosum*
4. Only ventral markings are a black ganglionic area on median line of each sternite. Claws of second and third legs approximately equal to respective tarsi in length ..... *Sp.?* No. 1.

Distribution of Siphloplecton in the state

Three species of the genus Siphloplecton were taken, all of them from the piedmont region. One of these is represented by nymphs only, one by adults only, the third by nymphs and reared imagoes.

Siphloplecton basalis Wlk. ?

On March 24, 1929, a pair of imagoes were taken in flight over a small stream in a wooded area seven miles northeast of Spero. Comparison of the male with a specimen of *S. basalis* sent by Mr. F. P. Ide to the Cornell collection, and with the description of this species by Clemens (as *S. flexus*) show it to be very similar, but with these differences: 1), eye color dark grey, not dark brown; 2), wing darker—brown areas of costal region darker in color, and basal dark areas of both wings more extensive; 3), red areas along median ventral line of abdomen either absent

or much reduced, while the dark dots on each side are more prominent; 4), tails darker brown; 5), spines present on penes (none observed on *S. basalis*); 6), end joints of forceps relatively shorter; 7), spines of fore tibia stouter; 8), head, thorax and abdominal tergites lighter in color but latter with approximately same color pattern. The posterior margin of the 9th sternite of the female is shown on Pl. 12, Fig. 29. No female of *S. basalis* is available for comparison. No nymphs of this species were found. For the present, this species will be considered as a probable *S. basalis*.

Siphloplecton signatum, sp. nov.

On Feb. 18, 1930, three mature nymphs of Siphloplecton were taken from a small artificial lake about three miles west of Liberty, N. C. All three emerged before 8 p.m. that evening. On March 16, several more mature nymphs were taken from the same lake. By Mch. 19 these had all emerged. They proved to be representatives of a new species, the adults being lighter in color than *S. basalis*, and differing from the light-colored *S. interlineata* as is indicated further on. The description of the new species is as follows.

MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Male nymph (4 specimens)	11–13	3½–5		
Female nymph (2 specimens)	13–16	5		
Male imago (1 specimen)	14	25	11½	14
Female imago (4 specimens)	15–16½	17–18	13½–15	7½–10

Slightly larger than *S. interlineata* Wlsh., but in general very similar to it, the male having the same whitish abdomen. Distinguishable however from this species by the lack of a "coarse medial black line immediately below the third vein of the costa" (Walsh, 1862, p. 369); by the pattern of the abdominal tergites and the color of the tails; and by the lack of a white band between the hind coxae, in the male. From *S. basalis* Wlk., which it resembles in size, it may be separated by the whitish abdomen and the lighter color of the thorax. The nymph has but a single brown median ventral streak, which character separates it from other known nymphs of this genus.

Nymph

Head—Light brown; labrum and tips of mouthparts darker. Compound eyes black. Ocelli ringed with black, the median smaller than the lateral ones. Basal and last two or three distal segments of antenna dark brown, remainder light tan. Mouthparts very similar to *S. basalis*.

Thorax—Light tan dorsally, with irregular brown blotches on each side of mesonotum anterior to the wing roots. Cream colored to light tan ventrally.

Legs—Cream colored in younger nymph, light brown in mature forms. Two light brown transverse bands, one-sixth from basal end and one-fourth from distal end of each femur. Brown transverse bands also at center of tibia, and one-third from basal end of tarsus, the latter sometimes a darker brown. Claws of second and third legs approximately four-fifths of tarsus. Femur of second and third legs about equal to tibia and tarsus combined. Femur of foreleg about two-thirds of combined tibia and tarsus. Fore tarsus 1 as long as tibia; corresponding joint of other legs very similar in length.

Abdomen—Cream colored with brown markings. Narrow dark line along center of anterior margin of each tergite, and a brown spot in center of each pleural extension. Tergite 1 brown in anterior third. Tergite 2 with two short brown marks on each side of median line, from anterior margin. On 3 to 5, a triangular brown blotch (wide and long on 3, short on 4 and 5) at some distance from median line on each side. Laterad of this mark are two narrow oblique parallel lines. Tergite 6 with large irregular brown blotch on each side of center, extending backward to posterior margin and laterally to pleural extension. Dark wedge-shaped spot on median line at anterior margin. Oblique brown line in center of anterior lateral angle. 7 and 8 with two small brown spots on each side near anterior margin, one near median line, the other halfway to pleural fold. On each side of median line at center of tergite, a short brown streak. 9 marked like 8, but in addition a large brown wedge-shaped blotch occupies the center of the tergite on each side of the median line. 10 has two brown spots on each side, one above the other near the median line, and two brown streaks on the median line, one just back of the anterior margin, the other near the center. A brown mark in anterior lateral angle.

Ventrally, a wide dark brown streak occupies the median line. It is continuous from 3 to beyond the center of 9, except for a few short breaks at anterior and posterior margins of 3 and 4. Represented on 2 by

three spots, the anterior one largest. Streak varies in width, widening most at ganglionic area and again near center of each sternite. Two short bars on each side of 10, on anterior margin.

Gills—Double on segments 1–3, single on all others.

Tails—Cream colored in immature nymphs, brown in mature ones. All three crossed near distal end by very dark brown band.

Male imago

Head—Compound eyes dark grey, lighter on upper portion; contiguous. Ocelli whitish, ringed with dark brown. Basal segments of antenna white, filament brown, lighter again at tip. Frons greyish white with brownish area on each side of median carina. A transverse band beneath bases of ocelli.

Thorax—Pronotum greyish white in posterior third; anterior part dark brown. Mesonotum cream colored to light tan, bordered laterally with dark brown; posterior spine also brown. Metanotum dark brown. Pleura tan, sutures dark brown. Prosternum greyish white. In anterior half a brown median stripe, and a transverse brown streak between coxae. Central anterior portion and posterior margin of mesosternum very dark brown; remainder light brown margined laterally with dark brown, except for greyish white transverse band anterior to second pair of legs. Metasternum dark brown.

Legs—Femur of foreleg light brown, other joints cream colored to light tan. Light brown at joinings except femoro-tibial joint, which is dark brown. Claws purplish brown on outer margin. A transverse brown band near distal end of femur. Second and third legs light brown, joinings dark brown. Transverse brown bands on femur near distal end, and on tibia one-third from basal end. Claws as in foreleg. Tarsal joints of foreleg, in descending order: 1, 2 and 3 (equal), 4, 5. Tarsus three times length of tibia. Tibia five-sixths of femur. Tarsal joints of third leg: 1, 2, 5, 3, 4. Tarsus and femur approximately equal. Tibia two-thirds of femur and of tarsus.

Wings—Brown areas in both fore and hind wings much as in *S. basalis* Wlk. Wings transparent in other parts. Longitudinal veins in upper half of forewing dark brown, all but the three of the costal border shading into light brown apically. Other longitudinal veins light brown, also in upper half of hind wing. Cross veins of cell areas C., Sc, and Rs of forewing, also most of those in disc of wing, margined with dark brown. Other cross veins likewise brown except those near margins, which are mostly yellow. Veins in lower half of hind wing yellow.

Clouded areas at base of fore and hind wings as extensive as in *S. basalis.*

Abdomen—Tergite 1 dark brown except a white band next to posterior margin. Brown marks are a semicircular portion on each side of median line, superimposed on a lighter rectangular area. Center of posterior margin dark brown. Tergites 2–5 with cream background and light brown markings. On each a crescentic brown area next to pleural fold. A triangle with its base on the posterior margin extends forward along the median line, its apex reaching the anterior margin. From base of this triangle on each side are two forward projections ending in elongated spots near center of tergite. Bounding this brown area on the outside are two parallel rows of blackish-brown dashes, extending from near the center of the anterior margin outward and downward to the posterior margin on each side of the brown triangle. On posterior margin a median dark brown spot and a larger dash on each side. 6–8 mainly dark brown, but with a large cream colored triangular area on each side near pleural fold, its base on anterior margin, its apex extending beyond center of tergite. On each side of median line at center of tergite, two whitish dashes. On 6, parallel dashes as on 2–5, but darker and more numerous. 9 entirely dark brown save for small triangle on each side anteriorly. 10 dark brown, lighter on sides, median line darker.

Ventrally, sternite 1 dark brown bordered on sides and posteriorly with cream-white band. Sternites 2 and 8 light tan; 9 and 10 slightly darker brown. Other sternites cream colored, with very small dark reddish brown spot over ganglionic area of each, and indistinct tan bars arising from posterior margin, parallel to median line, and extending forward beyond center of sternite.

Tails—Light tan with reddish brown joinings, alternate ones wider. Finely pilose throughout length.

Genitalia—Light brown. Very similar to *S. basalis* in general appearance. See Pl. 11, Figs. 5 and 13.

Female imago

Differs from male in following respects. Antennae brown basally. Vertex and occiput olive brown. Thorax lighter dorsally and laterally. On some specimens mesonotum light olive brown. Prominent white band anterior to mesothoracic legs. Femur and tibia of foreleg light brown, tarsus dark brown, joinings darker. Markings of tergites somewhat as in male but more extensive, and reddish brown on flesh-colored

background. No blackish dashes in parallel rows on each side. All tergites marked much like 6–8 of male. In addition, on 6–9 a whitish streak anteriorly on each side of the dark bar next to the pleural fold. Median line indistinctly darker on posterior segments in some specimens. Anterior segments bordered widely and posterior ones narrowly with white along center of posterior margin. Sternites flesh-pink, median line a deeper pink. No ganglionic mark. On each side of sternites 2–7, above center in anterior segments but at center in others, a small brown oblong spot. Behind this and nearer the center line, a very minute dark dot, indistinct on some segments. On 8 and 9, two dark bars parallel to median line, one on each side. Forewing as in male. Hind wing lacking clouded basal area. Apical margin of 9th sternite as on Pl. 12, Fig. 31.

Holotype—♂ imago. Small lake near Liberty, N. C. Reared from nymph, Feb. 18, 1930. No. 1021.1 in C. U. collection

Allotype—♀ imago. Same location. Reared same date. No. 1021.2 in C. U. collection.

Paratypes—2 ♀ imagoes. Same location. Reared March 19, 1930. No. 1021.3–.4 in C. U. collection.

Siphloplecton sp.? No. 1.

Immature nymphs of a species of Siphloplecton were taken on Oct. 19, 1929, from Big Alamance Creek, south of Greensboro. These proved to be neither *S. basalis* Wlk., *S. signatum* n. sp., nor a new species from Georgia, *S. speciosum*. The Alamance Creek nymphs differ from the others in their color pattern and in the fact that on all the segments the gills are single. There remains the possibility that these may be nymphs of *S. interlineata* Wlsh. or *S. fermorata* Say, the only two species in the genus the nymphs of which are not known. A brief description of these nymphs follows. As they were immature, no measurements are given.

Antennae white with black tips. Mouthparts very similar to *S. basalis* and *S. signatum*. Legs long for length of body, the foreleg being equal in length (in immature nymph) to head, thorax and first two abdominal segments. Claws of second and third legs equal or nearly equal to tarsus in length. Tibia of these legs shorter than tarsus; femur approximately equal to tibia and tarsus combined. Tarsus of foreleg only slightly longer than tibia; femur five-sevenths of combined tibia and tarsus. Two transverse bands on femur; tibia and tarsus unmarked.

Gills single on all segments, more simple in form than those of *S. basalis* or *S. signatum* (see Pl. 12, Fig. 16.). Tails with black band near distal end. Dark brown spot in center of each pleural extension. Ventral abdominal markings consist only of a small black spot at the ganglionic area in each sternite. There is no slightest indication of a continuous ventral dark stripe.

Siphloplecton speciosum, sp. nov.

Prof. P. W. Fattig, of Emory University, Ga., collected many nymphs of a new species of Siphloplecton during March and April, 1931, which were sent to Prof. J. G. Needham at Cornell University. Several of these Prof. Fattig reared successfully to the imago stage. These nymphs were taken from a creek near Macon, Ga., on March 22; from Big Indian Creek and Flat Creek on April 3; from Oochee Creek near Groveton, and Echeconee Creek near Macon, on April 10. Subimagoes emerged from April 15 to 17, usually requiring approximately 48 hours to complete their transformation.

This is a beautiful species, both in the nymphal and the imaginal stages. Nymphs have a continuous dark brown mid-ventral line from sternite 3 to 9; two black dots on each side of the sternite near the pleural fold; and white gills with black tracheae. Imago males have silvery abdominal sternites, no clouded areas on either wing, whitish eyes, very dark thorax, and the anterior and posterior abdominal tergites likewise very dark brown.

MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Male nymph (7 specimens)	9–12	3½–3¾		
Female nymph (7 specimens)	13–16	4½–5		
Male imago (8 specimens)	9–12	14–19	8½–10	9½–12
Female imago (3 specimens)	11–12½	14–18	11	6–6½

Nymph

General color of mature male nymph cream-yellow; of female nymph brown dorsally, light tan ventrally. Both marked with brown.

Head—Dark brown transverse band across frons below bases of antennae. Antennae light tan, black near tip; extreme tip white.

Thorax—Mottled irregularly with brown.

Legs—Light brown, marked with darker brown as follows. A dark

band near each end of each femur; one at basal end of tibia; a narrower one one-third from basal end of tarsus. Claws of second and third legs approximately equal to three-fourths of their respective tarsi. Femur of second and third leg equal to combined tibia and tarsus. Femur of first leg less than combined tibia and tarsus. Tibia of second and third leg shorter than tarsus, each about equal to four-fifths of tarsus. Tibia of foreleg slightly longer than tarsus.

Abdomen—Tergites 1, 6 and 9 often with large brown blotches; others with smaller brown blotches, as indicated. Blackish brown spot on each tergite in center of pleural extension. Posterior margins of tergites dark brown at center, then lighter, then another dark spot. A grey-brown patch near center of tergites 3–5, 7 and 8. Posterior to this on each side a similar patch. Anterior to it on each side a somewhat darker patch. Near it on each side a very small dark spot. Near pleural fold a dark brown oblique band. Ventrally a black or very dark brown rather wide median stripe, continuous from middle of sternite 3 to end of 9. Small dark spot on ganglionic area of 3; 10 lacking central stripe. Greenish brown median triangle from posterior margin of each sternite from 1 to 7, its apex on anterior margin, through which the blackish band extends. Near pleural fold on each side a narrower greenish band, and on this in each sternite from 2 to 7 are two black spots, one near each margin. In 8, anterior one only is present. On 9, two longitudinal stripes.

Gills—Double on segments 1–3, single on 4–7. White with prominent black tracheae.

Tails—In immature nymph, light yellow. In mature nymph, middle tail yellow, outer ones light brown. Joinings purplish brown. All three crossed by black band near tip.

Male imago

Head—Frons white, crossed by wide brown band beneath bases of antennae. Vertex and occiput brown. Compound eyes greyish white, crossed near the base by a wide and a narrow purplish band. Ocelli greyish white. Basal segments of antennae brown except for whitish outer surface. Filament brown in basal half, distally greyish.

Thorax—Very dark brown. Posterior lateral margins of pronotum white. Mesonotal spine margined anteriorly with cream color. Pleura lighter brown than tergites and sternites; white between sclerites. White transverse band posterior to fore legs. Similar bands anterior to coxae of second and third pairs of legs. Prosternum, anterior sclerite of

mesosternum, and posterior margin of metasternum, much darker than other portions.

Legs—White spot on outer side of each coxa. Femur and tibia of foreleg brown, femur with wide reddish brown band near distal end, and indistinct darker band basally. Tarsus grey to grey-brown, darker at joinings. Femora of other legs light brown, dark band near each end. Tibia and tarsus grey, former with wide band near basal end. Joinings darker. Foreleg as long as body. Tarsal joints, in descending order: 1, 3, 2, 4, 5. Tarsus equals three times length of tibia. Tibia equal to four-fifths of femur. Tarsi of second and third legs equal 1½ length of tibia.

Wings—Transparent. No dark clouded areas on either wing, nor cross veins widely bordered with brown, as in other species of the genus. Apical portion of cells C and Sc milky. Humeral cross vein, bases of upper longitudinal veins, and median vein of fore wing light purplish brown. Other longitudinal and cross veins hyaline. At bulla, three purplish black spots; first on vein Sc; second, on vein second below Sc; third, on second vein below the latter.

Abdomen—Tergites 1 and 2, posterior half of 7, all of 8 and 9, and central portion of 10, very dark brown. Lateral margins of 8 and 9, and posterior lateral angles of 10, white. Tergites 3–6, and anterior half of 7, white with darker markings. 2 to 6 margined posteriorly with purplish red. On anterior half of these tergites, a similarly colored streak on mid-dorsal line, and similar short marks in center of each, just lateral to median line. A light brown triangle based on the posterior margin occupies the posterior lateral angles of 2–6; in this triangle, two irregular reddish marks. A smaller triangular spot on posterior margin on each side of median line. Two parallel rows of indistinct black pencillings from center of anterior margin outward and downward to posterior margin.

Ventrally, sternite 1 dark brown, margined narrowly with white. Sternites 2–6 silvery white; 7–9 opaque powder-white. 5 and 6 faintly tinged with yellow. On 2, an oblong brown spot on each side in anterior half, a little distance from median line. Below it and nearer the center, a smaller dark dot. Very small reddish ganglionic mark on 2–6. On 7 and 8 this mark is larger and quite distinct. On 8 an oblong brownish mark in center of sternite, one on each side of median line.

Genitalia—Greyish white. Quit similar to *S. basalis* and *S. signatum*, but differing somewhat in shape of penes and in presence of several short spines on basal portion of latter. See Pl. 11, Figs. 2 and 19.

Tails—Greyish white. Joinings purplish.

Female imago

Differs from male in these respects. Thorax light red-brown, marked with white as in male. Tergites red-brown, margins and pleural folds white. Purplish red spots as in male. Small dark spot in center of posterior margin on 1–7, and median line dark brown in anterior half of all tergites. In posterior lateral angle of pleural folds of 3–7, a small black spot. Sternite 1 brownish red. Sternites 2–10 flesh-colored; small dark ganglionic spot on 5–9.

Holotype—♂ imago. Echeconee Creek, Ga. Reared from nymph by Prof. P. W. Fattig, April 16, 1931. No. 1022.1 in C.U. collection.
Allotype—♀ imago. Same data. No. 1022.2.
Paratypes—1 ♀ imago, 5 ♂ imagoes. Same data, but dates April 14–17. No. 1022.3–8.

GENUS AMELETUS Eaton 1885

Key to Ameletus nymphs of eastern United States

1. With three distinct stripes on venter of abdomen 2
   Without any ventral abdominal markings ..... sp? No. 2
2. Stripes continuous, both lateral and medial ones 3
   Median stripe continuous only on 8–10; discontinuous anteriorly ... sp? No. 1
3. Stripes wide, their edges not clearly defined; fused on last three posterior sternites. No continuous white line between each lateral stripe and the pleural extensions ..... *ludens*
   Stripes relatively narrower, edges clearly defined; fused only at posterior margin of sternite 9. Continuous white line present between each lateral stripe and the pleural extension ..... *lineatus*

Distribution of Ameletus in the state

Three species of this genus were taken in the state, two from the piedmont and one from the Appalachian region, the latter collected by Prof. J. G. Needham. Two of these are represented by nymphs alone. Only one species of Ameletus has hitherto been described from eastern North America,—*Ameletus ludens* Needham. Comparison of the three species from North Carolina with type material of *A. ludens* indicates that the latter is not represented among them. The specimens from North Carolina seem to represent new species.

Ameletus lineatus, sp. nov.

The nymph of this species is recognizable by its relatively large size and the three conspicuous brown stripes on the venter of the abdomen.

MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Female nymph (4 specimens)	12–14	3½–5½		
Female subimago (3 specimens)	11	9–10	11–12	5–6

The subimago differs from *A. ludens* in the lack of any dark markings over the ganglionic areas.

Nymph

Head—Brown. Basal segments of antenna brown; yellowish white area for about one-third of remaining length, beyond which is a broad dark brown band not extending to the tip, which is white. Two parallel longitudinal brown bars on vertex, and brownish areas at median line on posterior margin of occiput. *Mouthparts* quite similar to *A. ludens*, but maxillary palp is slightly longer proportionately. Maxilla shown on Pl. 12, Fig. 6.

Thorax—Dorsally, cream yellow mottled with light brown. Pleura and ventral surface whitish, the former with a few brown marks. Legs relatively much stouter than in *A. ludens*. Light brown, marked with dark brown as follows. Brown bands at proximal end of femur; one-third from distal end of femur; at proximal ends of both tibia and tarsus; narrow band at distal end of tibia; wide band at distal end of tarsus. Claw brown, somewhat stout at base. Femur of foreleg equal to 1½ length of tibia. Tibia slightly longer than tarsus. Claw of third leg equal to ½ length of tarsus.

Abdomen—Dorsally, cream yellow and dark brown. Tergites 1–5 mottled cream white and brown, the brown areas being on anterior and posterior margins, center and next to pleural fold of tergites, thus leaving central region on each side of median brown area cream colored. Dark brown spots near posterior lateral angles of pleural extensions. Tergites 6 and 7 predominantly cream colored, the brown areas being restricted to the margins and median line, and a dark bar enclosed in a cream colored area on each side median line at center of tergite. 8 with oblong cream colored marks near anterior margin. 8–10 predominantly dark brown. Cream colored bar in anterior lateral angle of each. Posterior margin cream-yellow, 10 cream colored also on median line.

Ventrally, whitish on anterior and yellowish on posterior sternites. Three continuous wide dark brown streaks extend the entire length of abdomen; one is median, two are lateral. The lateral streaks enclose a

light spot near the anterior margin on each sternite. A white streak separates each lateral streak from the pleural extension. A small dark spot on each side, sometimes indistinct, close to median line at center of sternites 4–7.

Gills—Whitish, with narrow brown line just inside each outer margin.

Tails—Yellowish white, barred as in other species of the genus with two dark brown bands, a broad one one-third from base, a narrow one at the tip.

Female subimago

Head—Yellowish brown. Two parallel dark brown lines on vertex and occiput. Antenna dark brown. Ocelli ivory-white, widely ringed with black at base. Compound eyes purplish grey, a darker line marking off an upper and a lower portion.

Thorax—Dark yellowish brown. Mesonotum olive-brown in center, margined anteriorly and laterally above wing roots by dark chestnut brown. Mesonotal spine margined laterally with blackish brown. Two longitudinal dark bars on pronotum, one at extreme lateral edge, other somewhat toward the center from first. Pleura darker between sclerites. Posterior portions of pro- and mesosterna darker than other parts of the venter.

Wings—Uniform smoky brown.

Legs—Brown. Coxa, distal end of last tarsal joint, and joinings, very dark brown.

Abdomen—Tergites orange-brown, margined posteriorly with darker border. Pleural folds cream colored to light tan. An indistinct darker spot on each side of median line near center of each tergite.

Ventrally, lighter orange-brown, except sternite 7, which is as dark as tergites. An indistinct dark spot on each side of median line near center of each sternite, much as in tergites. No marks at ganglionic areas.

Tails—Very dark brown. In basal half, narrow black ring at each joining.

Female imago

Two of the female subimagoes died while endeavoring to complete their transformation. The subimaginal skin was carefully removed from one of these, and the coloration of the imago thus observed. It differs from the subimago just described in these particulars.

Prothorax margined narrowly on posterior border by purplish black.

Mesonotum clear greenish yellow, no darker markings, except blackish lateral margins of mesonotal spine. Pleura, thoracic sternites and legs lighter than in subimago, except posterior portions of pro- and mesosterna, which remain dark brown. Tergites of abdomen flesh-colored, each margined rather widely on sides next to pleural fold and along posterior border with orange-brown. Indistinct darker markings on each side of median line. Sternites 1–6 likewise flesh-colored, but 6 with purplish median mark. 7 flesh-colored in anterior half. Posterior half of 7, and 8–10, light olive-brown. Whitish triangles in anterior lateral angles of 8. Tails purplish brown, joinings darker. Apical margins of 9th sternite as on Pl. 12, Fig. 26.

Holotype—♀ subimago. Reared from nymph, Big Alamance Creek, N. C., Feb. 20, 1930. No. 1079.1 in C. U. collection.
Paratypes—2 ♀ subimago. Same data, Feb. 28, 1930. No. 1079.2–3 in C. U. collection.

On March 10, 1929, several nymphs of *Ameletus lineatus* were taken from Big Alamance Creek, in an area of gravel-and-sand bottom and not very rapid water. Again on Mch. 17 a few of these nymphs were collected from the same stream. In a small rapid-flowing tributary of the main stream several others were found. All but one of these died without transforming.

On Feb. 25, 1930, several more nymphs were collected from the same small tributary stream and also from the main stream of Big Alamance. Of these, three became subimagoes, but none successfully reached the imago state. All of these nymphs were females.

Ameletus sp? No. 1

Four small bluish grey nymphs were found in the tributary of Alamance Creek on March 10, 1929, along with the much larger nymphs of *A. lineatus*. No adults were reared from them. These seem quite distinct from both *A. ludens* and *A. lineatus*, but due to lack of adult forms will be considered only as *Ameletus* sp? No. 1. All of these were females. A description of these nymphs follows.

Nymph

Size—Body, 9–9½ mm.; tails 4½ mm.

General appearance—Bluish grey, varying in different nymphs in the extent to which it is present on the parts of the body. One very young

nymph (not included in above measurements) shows this color in thorax and gill only. One mature nymph has the posterior abdominal segments brownish, the remainder of the body bluish grey.

Head—Two brown streaks on vertex, light brown triangular areas on each side of posterior margin of occiput, near median line. Brown spot at base of mandible; other brown spots laterad of ocelli and bases of antennae and between ocelli. Antenna white basally, crossed near tip by a light brown band; tip white. *Mouthparts* very similar to *A. ludens*.

Thorax—Bluish, marked with brown. A band on each side of center of prothorax, and along lateral margin. Irregular brown markings on mesonotum, including one on each side near anterior margin, and two on each side of median line near posterior margin. Metanotum with brown mark on each side of median line, continued laterally from the posterior end as a border parallel to the posterior margin. Brown spots on pleura above and anterior to each coxa. Thoracic sternites uniform bluish grey.

Legs—Coxa, trochanter and basal portion of femur of each leg bluish. Remainder of leg yellowish white marked with brown. Brown spot on each coxa; near each end of femur; at base of tibia; and at basal and distal ends of tarsus. Femur of foreleg equal to $1\frac{2}{3}$ length of tibia. Tarsus slightly longer than tibia. Claw of third leg slightly exceeding one-third the length of the tarsus.

Abdomen—Tergites marked with brown as follows. A small dark spot in posterior lateral angle of each pleural extension, and a round dark spot in center of anterior lateral angle. Oblique brown mark extending from anterior margin on each side of median line on tergites 2, 3, 6, and 7. Tergites 1, 4, 5, and 8 with large brown blotch occupying middle of each, on median line; this blotch widest posteriorly and just anterior to center. Tergite 9 with brown blotch shaped like a right-angle triangle on each side of median line, its base on anterior margin. 10 with a brown streak on each side of median line, connected basally with another brown streak extending laterally to pleural fold.

Ventrally, three brown streaks, two lateral and one median in position, of which the median is discontinuous except on sternites 8–10. It is represented on 7 by a brown triangle near the posterior margin, its apex extending beyond center, and by a small brown line at the anterior margin. 4, 5 and 6 have each a brown mark posterior to the center; wedge-shaped on 6, rather oblong on 4 and 5. 1–3 lacking any median marks. Lateral lines continuous from 3–9, enclosing small white marks near anterior margin of each sternite. An indistinct oblique line extend-

ing a short distance from anterior margin, on each side of median line, on sternites 2–5.

Gills—Bluish grey. Along each margin a narrow brown line.

Tails—Light tan basally, yellowish distally. Crossed by wide blackish band one-third from base, and by narrower one at tip.

Ameletus sp.? No. 2

Several mature nymphs were collected by Prof. Needham at Highlands, N. C., on April 7, 1929. No adults were reared from them. A brief description of these nymphs is given.

Nymph

Size—One male nymph was among the specimens. Its body measured 8 mm., tails 4 mm. The bodies of three females measured 9–11 mm., tails 4–4½ mm.

General color yellowish brown.

Head—Without distinct marks, except two brown bars on frons, one below each antenna. Antenna black-tipped; just below this tip a white band. Remainder light brown, slightly darker distally. Maxillary palp relatively longer than in the other eastern species; end joint and basal joint longer respectively. See Pl. 12, Fig. 12.

Thorax—Marked dorsally with light brown. Metanotum with dark bands along anterior margin and beside median line. Unmarked ventrally.

Legs—Yellowish. Brown at joinings. Light brown band at center of femur, darker band at distal end of tarsus. Spines on femur brown. Femur of foreleg not quite equal to 1½ length of tibia. Tarsus slightly shorter than tibia. Claw of third leg almost equal to one-third length of tarsus.

Abdomen—Tergites 1, 2, 7, 8 and 10 predominantly yellowish. Others mainly brown, except for yellow areas along pleural extensions and at center of each tergite halfway between median line and pleural fold. Tergite 1 with brown area occupying center. Two small oblique marks on 2, on each side of median line, below anterior margin. 7 and 8 brown along anterior margin, extensions to center along median line, and brown blotch in posterior lateral angle near pleural fold. Two brown blotches on each side of median line of 10; anterior one larger. Brown spot on posterior lateral angles of pleural extensions 1–8. Ventrally, no markings.

Gills—Yellowish white, outer margins brown, wider on inside.

Tails—Yellowish basally, silvery distally. Crossed by usual broad blackish band near base, narrower one at tip.

GENUS ISONYCHIA Eaton 1871

Key to North Carolina species of Isonychia—Imagoes

1. Tails ringed at each joining with red or brown..... 2
   Tails not ringed with red or brown, except a few joinings near base..... 3
2. Wing of female 13 mm. in length. Second leg purplish brown on tarsus and distal end of tibia; last two segments of third leg same color.....*notata*
   Wing of female 10 mm. in length. Second and third legs purplish brown only on claws, distal portion of last tarsal segment, and tarsal joinings...*annulata*
3. Genitalia of the 'albomanicata' type. Tails largely whitish, joinings opaque. 4
   Genitalia of the 'arida' type. Tails largely dark brown..... 6
4. Venation dark brown. Abdomen light in color (flesh-colored to light orange). Fore tarsi not lighter than remaining segments of foreleg.....*pacoleta*
   Venation very light brown. Abdomen dark red. Fore tarsi lighter than remaining segments of foreleg..... 5
5. Forewing of female 13 mm. in length. Tarsi and claws of second and third legs of both sexes whitish. Tails ringed at base with very light red *albomanicata*
   Forewing of female 11 mm. in length. Tail reddish at base, with red joinings at base only. Claws and last tarsal segment of second and third legs of female light purplish grey.....*sicca* var. *manca*
6. Fore tarsi somewhat lighter in color than remaining segments of foreleg..... 7
   Fore tarsi not lighter in color than remaining segments of foreleg..... 8
7. Incurved portion of penes 'saw-toothed,' bearing 7–8 teeth or spines. Last three tarsal segments of second and third legs purplish.....*serrata*
   Incurved portion of penes bears but 2 teeth or spines on inner angle. Only distal segment of second and third tarsi purplish.....*georgiae*
8. Venter of abdomen marked with definite dark brown or purplish color pattern. 9
   Venter of abdomen without dark brown or purplish color pattern, except at openings of oviducts in female.....*aurea*
9. Fore wing of male 11 mm. Outer distal angle of penes acute, a deep indentation beneath it. Mesonotum of male very dark purplish to mahogany brown.....*obscura*
   Fore wing of male 12½ mm. Outer distal angle of penes rounded, no indentation beneath it. Mesonotum of male light mahogany brown.....*similis*

Key to North Carolina species of Isonychia—Nymphs

1. Antenna white at base. One dark spot in outer margin of gill..... 2
   Antenna brown at base. Two dark spots in outer margin of gill..... 3
2. Large species, females 13–16 mm. in length. Fore tibia with distinct wide greyish brown band in central portion.....*albomanicata*
   Smaller species, females 11 mm. in length. Fore tibia yellow except for narrow brownish streak at center of fore margin.....*sicca* var. *manca*

3. Antenna crossed by dark transverse band, about three segments wide, one-third of distance from base 4
Antenna not crossed by a dark transverse band as above 8
4. Small species, under 12 mm. in length ..... *annulata*
Larger species, 12 mm. or over in length 5
5. Fore leg predominantly yellow, with brown marks 6
Fore leg predominantly brown with narrow yellowish markings ..... *serrata*
6. Spines on fore tibia very numerous (over 30 in number) ..... *similis*
Spines on fore tibia less numerous (fewer than 25 in number) 7
7. Gills dark purple. Nymphs distinctly bronze in color ..... *georgiae*
Gills greyish lavender. Nymphs distinctly dark reddish brown in color. *notata*
8. Spines on fore tibia few in number (fewer than 15). Tergite 10 entirely reddish brown in color ..... *pacoleta*
Spines on fore tibia very numerous (over 35 in number). Tergite 10 yellowish in basal third ..... *aurea*

Notes on the Genus Isonychia

A comparative study of the nymphs and imagoes of ten species of this genus from North Carolina, as well as of the imagoes of *I. arida* and *I. sicca*, seems to justify the following conclusions, which are in the main in accord with Dr. McDunnough's notes regarding the genus (see Canad. Ent. **63**: 157–163. 1931). However, until more convincing evidence has been brought forward to indicate a synonymy between *I. bicolor* Wlk. and *I. albomanicata* Needham, I shall continue to regard the two as distinct species, of which *I. bicolor* is known only as a female subimago.

Imagoes

On the basis of the male genitalia and the apical extension of the 9th sternite of the female, the genus appears to fall into two main groups. The first of these I have termed the "albomanicata" group (Dr. McDunnough's "bicolor" group); the second, the "arida" group. In each case, the characteristic type of genitalia is known by the same name as the group. *I. intermedia* Etn. is not included in this grouping, although Eaton's description would seem to throw it into the first group.

Species of the "albomanicata" group have the penes more or less truncate distally, never with an incurved basal or lateral portion bearing teeth or spines. The distal border of the forceps base is deeply incised, so that the penes are visible above its margin for most of their length. Females of this group have the outer distal angles of the apical margin of the 9th sternite sharply acute, and the spaces between them deeply incised, either angularly or rounded. In this group I place *I. sicca* Walsh, *I. sicca* var. *manca* Etn., *I. sicca* var. *campestris* McD., *I. rufa* McD.,

and the new North Carolina species, *I. pacoleta*. Because of the simplicity of the penes lobes, the "sicca" species and varieties might be considered one subdivision, and the other species placed in a second subdivision. In the latter, the outer angle of the penes is broadly rounded, the outer margin undulating. For appearance of genitalia of *I. pacoleta*, see Pl. 10, Fig. 14.

To the "arida" group belong species in which the genitalia bear spines or teeth on an incurved flap-like portion located on each side at some distance below the distal outer angles of the penes. The distal border of the forceps base is only shallowly incised, thus hiding the penes except for the extreme distal portion. Females of this group have the distal outer angles of the 9th sternite rounded, the space between them only slightly incised, or with no real indentation present. To this group belong *I. arida* Say, *I. georgiae* McD., the four new species *I. annulata*, *I. obscura*, *I. similis* and *I. serrata*, and probably also *I. aurea* and *I. notata*. The two latter species are represented by females only, but the 9th sternites of these are similar to other females of the "arida" group. For the structure of the penes of the four new species first mentioned, see Pl. 10, Figs. 6, 16, 17, 19, 21, 22, 23, 24.

Nymphs—Generally speaking, the nymphs of the different species of Isonychia are very similar one to another. Aside from evident differences in size, certain structural differences are recognizable. Each fore femur bears a flange at its distal end, overlapping the basal end of the tibia. Each fore tibia bears on its forward border a double row of very long tawny hairs, and on its hinder border and its upper surface, few to many spines. The claws of each leg are serrate or dentate on the inner margin, the appearance of these varying somewhat in the different forms, as is shown in the figures presented under each of the new species, also for *I. albomanicata* and *I. manca*. The shape of the gills, while subject to considerable variation on each nymph, nevertheless seems to show specific differences in some instances. See figures of the third gill, under each of the new species. The frontal carina varies slightly in shape in different species, but it has not been considered advisable to attempt its use as a specific character. Mouthparts have been found so similar in all the species studied, as to be practically worthless for the separation of species. The figures of the mouthparts of *I. albomanicata* Needham (N. Y. State Bull. **86**: pl. 6. 1905) serve well for any known species of the genus.

Color differences, always subject to individual and age variations, are sometimes useful. Thus the markings of the antennae differ somewhat

in different species, being whitish at the base in some and dark basally in others; in several species, crossed about one-third from the base by a transverse black or brownish band. The gills vary as to the color of the base and central disc, of the margins and mid-line, and as to the number and color of spots in the outer margin. Presence or absence of marks on the head, pro- and mesonotum, and abdomen, have been used to help distinguish one species from another. The ground color and markings of the legs are likewise useful for this purpose. The two outer tails are fully a third longer than the middle one, and are often broken at the tips. A short account of the appearance of the tails of *I. albomanicata* will serve equally well for any of the others, except that the color in the basal half varies somewhat in the different species, as noted in the descriptions. Basal half dark reddish brown, fringed on the inner margin with purplish hairs. A blackish brown band crosses the middle of the tail; beyond this, a wide yellowish white area, then another dark band, about twice as wide as the first one. The extreme tip is usually whitish.

Distribution of the genus

Ten species of Isonychia were taken within the state, seven in the Appalachian region and four in the piedmont. Six of the seven from the Appalachian region and one from the piedmont proved to be new species. Descriptions of these are herewith presented. Besides these ten species, many nymphs were taken from the mountain region which were not reared. The eastern species *I. sicca* and *I. arida* are not represented among the imagoes in my material. I have not seen the type material of *I. intermedia*, described from Arizona, but a comparison of the description of this species with all the purplish-marked North Carolina forms leads me to believe that I do not have *I. intermedia*. Dr. McDunnough's two new species, *I. rufa* and *I. sicca* var. *campestris* seem also not to be represented. As to the species which I am tentatively calling *I. sicca* var. *manca*, the imagoes are quite similar in appearance to specimens sent to the Cornell collection by Mr. Walley, but the genitalia are not exactly similar to those figured by Dr. McDunnough.

Species from the piedmont

Isonychia albomanicata Needham

Immature nymphs were caught in a branch of the Uharie River, near the little settlement of Farmer, N. C., on April 3, 1929. None of these

was reared. Mature nymphs were taken from the rapids of Big Alamance Creek, south of Greensboro, May 17, 1929. By May 25, most of these had transformed. One female, emerging at 7 p.m., required from 22 to 26 hours to complete her transfomation.

Isonychia sicca var. **manca** Etn.

As previously stated, I refer my specimens tentatively to this species. Several nearly-mature nymphs were collected from Little Alamance Creek on Sept. 15, 1929. These were reared, and by Sept. 18 a male and a female had completed their transformation. This appears to be an autumn species, as contrasted with *I. albomanicata*, which matured in the spring. However, no evidence is at hand to prove that one or both of these species may not be two-brooded. Genitalia shown on Pl. 10, Fig. 25.

Isonychia pacoleta, n. sp. (See description under Appalachian species).

A single female was reared from a nymph taken in Big Alamance Creek on Oct. 1, 1929. No other specimen of this species was taken in the piedmont.

Isonychia annulata, sp. nov.

MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Male nymph (2 specimens)	9–10½	4		
Female nymph (5 specimens)	10–11½	3½–6½		
Male imago (1 specimen)	10	15	13	5¼
Female imago (1 specimen)	11	12	9½	5

Imagoes with large whitish blotches on the abdomen, between purplish brown markings. Tails ringed at each joining with purplish red. Veins of wings dark brown in male, especially in basal area and central disc of fore wing. Fore femur light basally; fore tarsus somewhat lighter than remaining joints of foreleg. Two dark spots in outer margin of gills of nymph.

Male imago

Head—Yellowish brown. Compound eyes grey with purplish tinge. Antenna light brown.

Thorax—Pronotum whitish with greyish purple markings. Mesonotum yellowish brown, on anterior portion and central area; reddish brown on sides and on mesonotal spine, which is margined posteriorly with dark brown. Whitish patch anterior to wing roots. Pleura creamy white, with light brownish markings. Prosternum creamy white, meso- and metasterna reddish brown.

Legs—Femur of foreleg whitish in basal half; distal half of femur and all of tibia except extreme basal end, light reddish brown. First four joints of tarsus light greyish brown; last joint and base of claws purplish grey. Second and third legs yellowish white except for claws, tarsal joinings, and last tarsal joint, which are faintly purplish grey.

Wings—Basal area and central area of forewing with very faint brownish cast, not distinct enough to form a cloud. Veins dark brown, darker in basal area. Stigmatic area faintly opaque whitish. Veins of forewing from 1st anal to margin united with one another in several places by cross veins. Very few marginal intercalaries in hind wing.

Abdomen—Cream white marked with purplish brown. Dorsally, a wide cream-white central streak extends the length of the abdomen, bordered on each side by a purplish brown line. Each tergite has a rather wide purplish black posterior border, except at the center. A purplish triangle, its base on the posterior margin halfway between median line and pleural fold, extends forward about three-fourths the length of the tergite. An irregular purplish mark, shorter than the triangle, extends forward from the posterior margin along the pleural fold, occupying all but the extreme angle of the posterior lateral area, which latter remains cream-white. Pleural fold margined narrowly with purplish black.

Posteriorly, sternite 1 entirely brownish. Sternites 2–5 each with a large central purplish-brown area, widest on posterior margin, bifurcated anteriorly, leaving the anterior half of the ventral region cream-white. On 6–9 a purplish bar or streak on each side of the median line, these bars approaching each other posteriorly on 8 and 9. A purplish black line parallels the pleural fold on each side, from posterior margin to center of sternite. At its upper end, a blackish dash. Between the pleural fold and the black line, a purplish area.

Tails—Cream-white, tinged with brown basally. Each joining purplish red.

Genitalia—Penes quite different from any thus far figured except *I. arida* and *I. georgiae*, which they resemble in a general way. Upper margin somewhat as in *I. albomanicata;* outer distal angle sharp-pointed,

each side indented slightly below the angle and then flaring out into a rounded projection. See Pl. 10, Figs. 21, 23. Outer margin of forceps base extending forward almost to the tips of the penes, but excised angularly in the center. Terminal joint of forceps limb slightly shorter than the penultimate joint. Forceps limbs purplish brown.

Female imago

Similar to male, except as indicated.

Head—Yellowish. Black marks as follows: one at each posterior angle of the occiput, extending onto the compound eyes and along their inner margin; one just cephalad of each compound eye; another on each side below the lateral carinae, between the margin and the median carina.

Thorax—Pronotum, mesonotum and pleura yellowish. Pronotum black in center of posterior margin. Irregularly marked with purplish brown. Ventrally with two purplish brown transverse bands, the anterior one broken at the posterior margin of the prosternum. Mesosternum flushed with purplish anteriorly, a median carina-like process likewise purplish.

Wings—Venation purplish brown except on costal border, which is yellowish brown, No indication of brownish cast in basal area and disc of forewing, as in male. Stigmatic area opaque whitish.

Abdomen—Very much as in male, but the first seven segments flushed with light purplish orange, probably due to presence of eggs. On tergites, the anterior portion of each dark triangle tends to become separated from the posterior or basal portion. All dorsal markings reddish brown rather than purplish as in male. Ventral markings reddish lavender. Posterior margin of each sternite pinkish lavender. Apical margin of both sternites as on Pl. 10, Fig. 7. Distal angles rounded, not sharp-pointed as in *I. albomanicata*. Incisure between these very shallow and rounded.

Tails—Faintly flushed with pink at base. Joinings as in male.

Subimagoes

Very similar to imagoes, but wings dusky brown, all coloring duller. Tails light greyish tan, joinings dark purplish brown.

Nymph

Bright reddish brown; head and thorax lighter than abdomen, and slightly yellowish in one specimen.

Head—Frontal carina white. Whitish median streak posterior to

the median ocellus, in one specimen mottled with light brown. Antenna dark brown at base, light tan for a short distance thereafter, then barred by a dark-brown band three joints in width. Remainder cream-white. Mouthparts very much as in *I. albomanicata.*

Thorax—Whitish median streak on pronotum, extending narrowly on to anterior edge of mesonotum. Pronotum with crescentic yellow marks on each side of the median line. Small white spots at and anterior to wing roots on mesonotum, and one on each side of the median line at level of wing roots. Lighter ventrally.

Legs—Dark reddish brown. Whitish bar between the dark markings. Distal half of tarsus, each end of tibia, each end and center of femur, light in color. Tibial spur of foreleg as on Pl. 10, Fig. 15e. Flange on distal end of fore femur as on Pl. 11, Fig. 4f.

Abdomen—In fully-mature nymph, the dorsal pattern is very similar to that of the adult insect, the markings very dark brown. Immature nymphs show, instead of this pattern, four white marks on each side. One on each side of median line at anterior edge; behind this and nearer the lateral margin, another round spot; one in each anterior lateral angle; another opposite center of pleural fold, a short distance in from the edge of the fold. Tergites 8 and 9 with black dashes in the place of the first pair of white ones, in anterior tergites. Tergite 10 white anteriorly, black posteriorly.

Ventrally, mature nymphs show the anteriorly-bifurcated dark central triangle of the adult insect, also a brownish purple border next to the pleural fold on each side, and a row of blackish dots just below the anterior margin at the inner edge of this border. Immature forms show faintly the same lateral border and row of dots, but near the center of each sternite are two indistinct whitish dashes in the anterior half, one on each side of the median line. Below these and between their lower ends are two dots, each near the median line.

Gills—Dark purplish brown on central disc, margined anteriorly with light brown, laterally and posteriorly with white. Two dark brownish spots in the outer margin, the posterior of these the larger. Third gill shown on Pl. 10, Fig. 8.

Tails—Very similar to *I. albomanicata.*

Holotype—Male imago. Reared from nymph. Big Alamance Creek, N. C., May 22, 1929. No. 1088.1 in C. U. collection.

Allotype—Female imago. Reared from nymph. Same data. No. 1088.2 in C. U. collection.

Paratype—Male subimago. Reared from nymph. Same data. No. 1088.3 in C. U. collection.

Species from the Appalachian region

Isonychia georgiae McD.

Nymphs taken in Davidson River in July 1930 were reared, the imagoes emerging on July 9 and 21. The genitalia of the male are so similar to the figure given by Dr. McDunnough of the genitalia of *I. georgiae* as to make it very probable that my North Carolina form is of that species. However, as my male specimen differs somewhat from the description given by Dr. McDunnough, I give a brief description of it, as well as of the undescribed female and nymph of this species.

Male imago

Head—Compound eyes dark grey-lavender. Greyish white between ocelli. Base of antenna purplish, filament grey. Keel of median carina red-purple. Black spot on each side, below lateral carina. White ventrally.

Thorax—Pronotum light brown in central area, greyish laterally. Posterior margin greyed lavender. Mesonotum yellow, borders light brown; spine purplish. Pleura cream-colored and light brown, washed with lavender on side and anterior to wing roots. Ventrally, posterior portion of prosternum purplish grey. Remainder red-brown.

Legs—Fore femur white basally, purple distally. Base of tibia white, remainder greyed lavender. Tibia very slender. Tarsus very light greyed lavender. Other legs white, washed with yellow. Tarsal joinings, claws and last tarsal segments, faintly purplish grey.

Wings—Veins purplish black. Slight tendency to anastomosis of cross veins in stigmatic area. Veins from first anal to margin tend to be twice branched, sometimes connected by cross veins.

Abdomen—Background of tergites light red-brown. Cream-white border next to pleural fold. Markings purplish brown with wash of red. Central light median streak entire length of abdomen. Anterior lateral angle, and band next to pleural fold, cream-colored. Between these light areas, a wide dark purplish brown band, bounded on each side by a somewhat crescentic bar. Pleural fold narrowly margined with dark purple. Ventrally, purplish with brown wash. Dark median area, divided into two portions by narrow light grey mid-ventral line. Dark purplish border next to pleural fold. Between these dark areas,

a lighter band, becoming wider posteriorly. Anterior margins light grey. Posterior margin of sternite 1 white, of others greyed lavender. On 2–8, light marks on central dark area, seeming to be etched on the dark surface. A curved dash on each side of median line, below anterior margin. On 2, four transverse light dots below this. Two such dots on 3–8. Black spot in anterior lateral angle, and dark bar from this along pleural fold.

Tails—Greyed purplish brown. Joinings slightly darker.

Genitalia—As figured by Dr. McDunnough (Canad. Ent. 63).

Female imago

Differs from the male as follows.

Head—Yellow. Dark purplish in posterior lateral angle of occiput.

Thorax—Pro- and metanotum yellowish.

Legs—Distal half of fore femur, and fore tibia, dark purple-brown. Tarsus dusky yellow to greenish brown. Other legs white. Tarsal joinings very narrowly purplish, claws purplish near base. Last tarsal joint faintly grey.

Abdomen—Background purplish rose. Median light dorsal line as in male, and similar dark crescents bordering it. Lateral crescents very slender, except on tergites 1–3, not reaching to anterior margin. Space between this and the central crescent light rose-purple except for dark posterior margin. Ventrally, a dark rose-purple streak next to pleural fold in posterior half of each sternite. Dark spot in anterior lateral angle as in male. Rose-colored median line quite distinct. Bordering this on each side, an irregular dark rose-purple streak; wide posteriorly, narrowing somewhat but wide again at center, narrow anteriorly. Light dashes and dots as in male, but indistinct. Posterior margin of egg valve with greyish border, the main portion purple. A dark brown spot on each side of posterior margin of egg valve, on sternite 8. Wide light space on each side of each sternite, between dark central area and dark lateral border. In posterior sternites this space is cream colored flushed with rose. Anteriorly it is deep rose. Apical margin of sternite 9 as on Pl. 10, Fig. 10.

Tails—Dark red-brown basally, becoming somewhat lighter brown in central portion, the distal third tan with rose tinge. At tip, greyish white. Joinings at base not evident; in central area, darker red-brown than joints; distally, rose-lavender.

Size—Body, 15 mm.; tails, 20 mm.; forewing, 13½ mm.; foreleg, 6 mm.

Nymph

Entire body bronze.

Head—Carina whitish. Antenna dark brown basally, yellow in remaining portion, except for black transverse band one-third from base. Occiput and venter mottled.

Thorax—Indistinct whitish marks on each side of pronotum, and anterior to wing roots on mesonotum.

Legs—Foreleg yellow, except for black band near base of tarsus, brown shadow near center of tibia, and two light brown bands on femur, one near each end. Tibial spine, and flange on distal end of femur of foreleg, and claw of third leg, as on Pl. 10, Fig. 15c, and Pl. 11, Fig. 4g. Hairs on foreleg bright orange in certain lights. Second and third legs yellow, banded with dark brown.

Abdomen—Tergites 1–5 show indistinct white spot on median line at anterior margin. Faint whitish dashes arise from each side of this spot, extending backwards slightly beyond the center of the tergite. On tergites 6–9, these dashes arise at the anterior margin. At the center on each side of each tergite, a little distance from the pleural fold, a round white spot. Tergite 10 yellow basally, dark red-brown distally. Ventrally, male shows the whitish central markings of the imago, with a dark spot on each side near the anterior lateral angle. White marks absent from female, except on last four sternites; present here, but indistinct. No dark spots.

Gills—Very much as in *I. serrata*. Dark purple, outer margin white, with two brown spots. See Pl. 11, Fig. 11.

Tails—Marked as in *I. albomanicata*. Deep bronze at base.

Size—Body, male nymph, 12 mm.; female, 13–15 mm. Tails of female, 7 mm.; broken in male specimens.

Isonychia notata, sp. nov.

MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Male nymph (1 specimen)	12	5½–6		
Female nymph (1 specimen)	13	5		
Female imago (1 specimen)	13	19	12	5

Thorax of imago greenish yellow. Abdomen yellow to light orange, marked with purplish brown. Basal half of fore femur yellowish, fore

tarsus only slightly lighter than tibia. Tails light purplish brown at base, greyish white distally, joinings prominently dark purplish brown. Nymph very dark reddish brown, lighter ventrally. Gills greyish lavender, two brown spots in outer margin.

Female imago

Head—Greenish yellow. Dark purplish spot in posterior angles of occiput. Antenna purplish. Black spot below lateral carina on each side, another anterior to each compound eye. Compound eyes bluish grey.

Thorax—Pronotum yellowish. Dark purple at center of posterior margin. Lateral borders marked with purplish grey. Mesonotum and pleura greenish yellow. Mesonotal spine faintly marked with lavender, also its lateral aspects. Pleura marked with greyish lavender. Metanotum yellowish brown, purple at center of posterior margin. A purplish brown spot on each side of median line at center of sclerite. Ventrally, two dark transverse bars, the anterior one discontinuous, between fore legs. Central sclerite of metasternum brown. Its anterior portion, and the median area of the metasternum, purplish.

Legs—Basal half of fore femur yellowish; distal half purplish brown, borders darker. Tibia greyed purplish brown, darker in basal half. Tarsus greyed lavender, joinings and claws darker. Tarsus and distal fourth of tibia of second leg, and last two tarsal joints of third leg, purplish brown with olive tinge. Other portions of these legs greenish white, the second tibia with a brown stain near each end of the whitish portion.

Wings—Transparent, iridescent. Venation light purplish rose. Stigmatic area opaque white. No forking nor anastomosis of cross veins in this area. Some of veins from 1st anal to margin, twice forked.

Abdomen—Dorsally, yellow tinged with light orange; 10th tergite brighter yellow, unmarked. Median light dorsal streak, bordered on each side by a dark purplish brown line extending the length of the tergite. Posterior border of each tergite dark purplish brown except at median line. Arising from the posterior margin halfway between the median line and the pleural fold, a light purplish brown mark, widest at the base, curves forward and outward, not quite attaining the anterior border. Between this and the pleural fold, a crescentic mark of the same color. One end of the crescent is in the pleural fold, the other in the space between this fold and the dark line mentioned above. Thus the crescent occupies most of the posterior lateral angle, its open side

toward the center of the tergite. Posterior half of pleural fold on each tergite margined with lavender.

Ventrally, light yellow. Posterior margin of each sternite purple. On each side of the light median line, an interrupted purplish brown streak, extending the length of the sternite, on 1–6, but on 7 and 8 not reaching the posterior margin. Central portion of lip of egg valve reddish purple. Between the longitudinal streaks on 8, a chestnut transverse bar, connected on each side to the outer edge of the egg valve by a short arm. On posterior portion of each sternite, a reddish purple streak borders the pleural fold. In the anterior portion of each, in line with this streak, a dark purple spot. Apical margin of 9th sternite as on Pl. 10, Fig. 1.

Tails—In basal two-thirds, light purplish brown; distal third greyish white. A short transition between these, light tan. Joinings dark purplish brown, quite prominent.

Nymph

Mature nymph dark reddish brown, lighter ventrally. Immature nymph deep orange-brown.

Head—Median line of vertex and occiput mottled whitish. White spots laterad of each lateral ocellus, and cephalad of median ocellus. Frontal carina whitish. Antenna dark brown at base, remaining portion yellowish brown, crossed by black transverse band one-third from base.

Thorax—Median line of entire dorsal aspect a wide whitish band, in immature nymph. In mature nymph, whitish band wide at anterior border of pronotum only, becoming narrower until it almost disappears at the mesonotal spine. Crescentic whitish mark on each side of pronotum, not far from median line. Halfway to lateral border, a large white blotch. One or two smaller white dots toward lateral border from this blotch. White spot on each side of median line of mesonotum, between inner margins of wing pads. Several small white spots anterior to wing roots. Pleura and ventral surface light reddish brown.

Legs—Dark reddish to purplish brown, with yellowish markings. Tarsi narrowly yellow at basal end, distal half also yellow. Fore tibia narrowly lighter at each end, other tibiae with rather wide yellow band distally. Femora yellow narrowly at each end, a wider discontinuous blotch near the center. Tibial spine and femoral flange of fore leg, and claw of third, as on Pl. 10, Fig. 15b, and Pl. 11, Fig. 3.

Abdomen—Immature nymph with wide dorsal median line. On mature nymph, only the anterior segments are light for their entire

length; others light at anterior border only. A yellowish white streak on each side of median line, arising from the white line near the anterior border, extends beyond the center of the tergite. A white spot on each side at the center, near pleural fold. Tergite 10 yellow basally, blackish brown distally. Ventrally, each ganglionic area is a large white blotch, from which extends on each side a white line outwards and backwards to the center of the sternite. Four white dots arranged transversely at center of each sternite. On posterior sternites, median line posterior to ganglionic area is likewise white. A dark spot near each anterior lateral angle.

Gills—Greyish lavender, the borders and median division brownish. Two purplish brown spots in the outer margin of each. See Pl. 10, Fig. 5.

Tails—Reddish brown as far as the first black transverse bar.

Holotype—Female imago. Reared from nymph. Bald Creek (tributary of Cane Creek in Yancey Co.) near town of Bald Creek, July 17, 1930. No. 1087.1 in C. U. collection.

Isonychia similis, sp. nov.

MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Male nymph (2 specimens)	12	Broken		
Female nymph (3 specimens)	14½–15	7–8		
Male imago (1 specimen)	12	18	12½	7
Female imago (2 specimens)	15–15½	20–21	15	7

The male described above is a specimen that died trying to shed its subimaginal skin, so that the lengths of tails and forelegs given above probably apply to the subimago stage, but the description is of the imago after the cuticle was artificially removed.

Male very dark purple-brown, marked with bronze. Female imago with greenish yellow thorax, abdomen flesh-colored with purplish rose markings. Tarsus of forelegs not lighter than other joints of the foreleg. Tails dark brown in basal half, lighter distally. Nymph dark olive brown washed with purplish red. Gills greyish lavender.

Male (subimago with cuticle removed)

Head—Yellowish brown. Compound eyes greyish purple, bordered with reddish purple. Median and lateral carinae reddish purple on

keels. Black bar below lateral carina. Base of antenna and basal half of filament purplish brown; distal portion greyish lavender.

Thorax—Pronotum red-brown; light tan on lateral borders, lavender along posterior margin. Mesonotum mahogany brown, margins and spot just cephalad of spine cream colored to light tan. Metanotum very dark mahogany brown. Pleura cream colored to light tan, with lavender markings anterior to wing roots and above third leg. Ventrally, pro- and mesosternum light brown, metasternum very dark mahogany brown.

Legs—Fore femur light purplish at base. Remainder of femur, tibia and tarsus very dark purple. Other legs greenish yellow, claws and tarsal joinings purplish grey.

Wings—Dusky brown before removal of subimaginal skin. Imaginal wings transparent, veins dark purple. Stigmatic area faintly opaque, the cross veins tending to fork and to anastomose. Numerous intercalaries and cross veins on outer margin of hind wing.

Abdomen—Tergite 1 entirely dark purplish brown, except for light spot on posterior margin at median line. Similar white spots, also a narrow light streak on anterior portion of median line, on tergites 2–6. A deep purple area borders this narrow light median line, becoming continuous with a wide purplish brown line on the posterior margin, occupying the posterior half of tergites 2–6. Along the pleural fold this dark area reaches almost to the anterior margin. This dark area is wide on 2–4, a narrow band or streak on 5–9, and on the latter more brown than purplish. On 2–5, a purple streak halfway between median line and pleural fold, from anterior margin to wide dark posterior band. Light bronze areas are thus left in the anterior half of these tergites, divided into two parts by the lateral purple streak. Tergites 6–8 similar, but median bronze strip wider, and the anterior bronze areas darker in color. Tergite mainly bronze, with dark posterior and lateral borders and a dark stripe on each side of center.

Ventrally, sternite 1 entirely deep purple. Sternites 2–5 light brozen or tan in anterior half, purplish brown posteriorly. Each has four lighter dots arranged transversely at the center, at the upper edge of the purplish area. Sternites 6–9 mainly light bronze or tan, the posterior margin deep purple and the posterior half of each sternite washed with lavender. No central light dots. Dark purple spot in each anterior lateral angle next to pleural fold. Behind this and next to fold, a purplish streak.

Tails—Purplish rose, slightly darker at extreme base, the distal third somewhat lighter. Joinings dark purplish brown.

Genitalia—Of the 'arida' type. Incurved portion of penes bears two large and two small teeth or spines. See Pl. 10, Figs. 6 and 16.

Female imago

Differs from male as follows.

Head—Yellowish white. Faint lavender shadow in posterior angle of occiput. Base of antenna flushed faintly with lavender, filament greyish.

Thorax—Pronotum yellowish, bordered with purple. Mesonotum yellowish with green tinge. Purplish at anterior margin on median line, and the lateral aspects of the spine purplish grey. Pleura greenish yellow with faint lavender markings. Ventrally, greenish yellow in anterior half. Central sclerite of mesosternum reddish brown, metasternum light purple.

Legs—On one specimen, basal third of fore leg whitish. Basal joint of tarsus on second and third legs greyish.

Wings—Venation purplish brown, darker than in male. Some of veins from 1st anal to margin twice-forked.

Abdomen—Tergites 1–7 orange, 8–10 yellow. Median line orange, bordered on each side by a purplish-brown streak, widest at base on 2–7, anteriorly on 8 and 9. Posterior margin and posterior lateral angles purplish brown. Tergite mainly orange. No dark band beside median line, but a lavender mark at the center of the tergite. Indistinct small lighter 'eye-spot' at upper end of each dark posterior lateral area. Ventrally, sternites 1–7 light orange, flushed with rose. An indistinct lighter median line. A light dot on each side of the median line near the center of sternites 2–4. Sternites 8–10 yellowish, 10 most definitely of this color. Posterior margin of egg value purplish brown. Lavender streak beside pleural fold in posterior half of each sternite. A purple dot in anterior lateral angle, in line with this streak.

Tails—Very dark purplish brown basally, lighter brown in distal half. Joinings darker brown.

Nymph

Body of mature nymph dark olive brown washed with purplish red. Immature forms dark brown with purplish markings.

Head—Yellowish spot cephalad of median ocellus, and laterad of each lateral ocellus. White median stripe on clypeus. Frontal carina brown. Vertex deep purplish brown, occiput olive brown with median light stripe at posterior margin. Antenna dark brown at base, other-

wise light yellowish brown. Indistinct dark brown transverse band one-third from base.

Thorax—Whitish median line, forming round blotch at anterior margin of pronotum. Three dark marks and two yellowish blotches on each side, between median line and lateral border. Whitish median line also on meso- and metanotum. On mesonotum, a wide triangle is formed at the anterior margin, and another between the inner margins of the wings, on the median line. On each side, a whitish spot and a dash on the inner borders of the wing pads, in line with the second white triangle. Several white spots anterior to wing roots, the largest in the anterior lateral angle. A purplish streak on each side of white median triangle at anterior margin. Metanotum mottled with purplish. Ventrally, light purplish grey.

Legs—Yellow, banded with purplish brown. Fore femur with purplish band one-third from base, another on hind angle of distal end. Tibia purplish in basal third. Tarsus with narrow basal and wider distal yellow area, the central portion very dark purple. Tarsi of second and third legs similar; femora all purplish but a yellow band one-third from distal end; tibiae purple in basal, yellow in distal halves. Tibial spine and femoral flange of fore leg and claw of third leg, as on Pl. 10, Fig. 15a; and Pl. 11, Fig. 4e.

Abdomen—Last three segments darker than anterior ones. Median dorsal line whitish in anterior half of tergites 1–6; on 7–9, only a light triangular spot at the anterior border. A dark purplish brown mark arises from the median line on each side, just behind the anterior border, extending outwards and backwards slightly beyond the center of the tergite, on 2–5. On 6–9, this is replaced by a narrow dark line paralleling the median line on each side, and attaining the posterior margin. Very small and indistinct white spots may be present at the posterior end of this dark mark, on 2–5. Posterior margin of each tergite purplish. Lateral margins of posterior tergites light brown. A white spot at center of tergite a short distance in from the pleural fold, bordered on the outer side by a very dark purplish mark. Tergite 10 yellow in basal half; distally blackish brown.

Ventrally, a white spot at each ganglionic area, these increasing in size posteriorly. Lateral margins light greyed lavender. Pleural fold margined with purple. A narrow purplish line at inner edge of the light margin. In mature nymphs, a dark spot in this line, near the anterior margin. Each sternite narrowly purplish on the posterior border. Four whitish dots arranged transversely across center of each sternite. Sternites 7–9 considerably darker than preceding ones.

Gills—Light greyish lavender; median line, margins, and two dark spots in outer margin, brown. Tracheae prominent,—lavender in color, as are also the gill tufts. See Pl. 11, Fig. 8.

Tails—Very dark brown at extreme base; from base to first dark transverse bar, yellowish brown. In mature male nymphs, outer tails purplish in this portion.

Holotype—Female imago. Reared from nymph. Cedar Creek (tributary of Tuckaseegee River) near Glenville, N. C., July 29, 1930. No. 1092.1 in C. U. collection.

Allotype—Male imago. Reared from nymph. Same location. July 24, 1930. No. 1092.2 in C. U. collection.

Paratype—Female imago. Reared. Same data as holotype. No. 1092.3 in C. U. collection.

Isonychia obscura sp. nov.

A dark purplish brown species. Represented by male imago only. Rather similar to *I. georgiae* McD. and the new species, *I. serrata*, but differing in the details of the penes. In general, a darker form than either of the latter species. I have not seen the type of *I. intermedia* described from Arizona, but from Eaton's description the North Carolina forms appear to be distinct from that species.

Size—Body, 12 mm ; tails, 17; forewing, 11; foreleg, 7½.

Head—Dark purplish brown. Purplish red spot at union of median and lateral carinae. Purplish spots below the antenna, two on each side of the head. Antenna dark purplish. Compound eyes bluish purple, the transverse band blue.

Thorax—Very dark purplish to mahogany brown, lighter at lateral borders of pronotum and on the pleura. Lavender mark anterior to wing roots. Mesonotal spine and metanotum so dark as to be almost black. Ventrally, light grey-purple on posterior portion of prosternum, otherwise very dark red-to-purple brown.

Legs—Basal half of fore femur light yellowish brown. Distal half of femur and all of tibia very dark purplish brown. Tarsus same color, a shade or two lighter. Second and third legs (judging by the one example that is preserved) white with faint greenish flush. Tarsal joinings and spot near center of claw purplish grey.

Wings—Venation dark purplish. Stigmatic area rather opaque white. Tendency for the cross veins of the stigmatic area to fork. Outer margin of hind wing with several intercalary and cross veins.

Abdomen—All of first tergite, posterior two-thirds of tergite 2, and posterior halves of tergites 3–6, dark purple. Anterior portion of the same tergites light purplish brown. Anterior lateral angle and an extension from this inward and backward for a short distance, light grey with lavender tinge. Extreme posterior angle same light color. Space between these, very dark purple. Extending backward from the anterior margin on each side of the median line, a dark purple streak, wider at its origin, reaching to the center of the tergite. A similar dark purple streak, arising from the posterior border between the first-mentioned streak and the pleural fold, reaches almost to the anterior margin, there expanding into a purplish blotch. Tergite 9 dark purplish brown with olive cast; two dark lines on each side at anterior margin. Tergite 10 light golden brown. Pleural fold margined with lavender.

Ventrally, lighter than in dorsal aspect. Sternites 2–6 purplish rose except a lighter median streak and a rather wide lateral border next to the pleural fold, which are cream to light greyed lavender. General effect is of a central light streak, bordered on each side by a band of purplish rose, this in turn bordered by grey. A very dark purple bar is parallel and close to the pleural fold in the posterior half of each sternite. Before reaching the anterior margin, it ends in a darker dash. Sternite 1 entirely deep purplish rose. Posterior margin of each sternite greyish purple. On 2–5, a transverse row of four light dots is seen. Sternites 7–9 lighter purplish rose, with an interrupted brownish streak on each side of the median line, ending at the center of the sternite as two dark dots.

Tails—Basal half very dark purplish brown, darker at joinings. Distal half very light grey, joinings reddish lavender. A short transition area of light grey with lavender wash is between the dark and light portions.

Genitalia—Of the 'arida' type. See Pl. 10, Fig. 24. Forceps base dark reddish brown. Forceps limbs purplish brown except light distal joint.

Holotype—Male imago. Penrose, N.C. Caught on window screen, July 17, 1930. No. 1086.1 in C. U. collection.

Isonychia pacoleta sp. nov.

Male imago, light orange, each abdominal segment bordered posteriorly with purplish brown. Fore tarsus light grey-lavender. Tails

MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Male nymph (2 specimens)	10–11	7		
Female nymph (3 specimens)	13–15	7		
Male imago (2 specimens)	11–12	23½–26	10	5½–7
Female imago (3 specimens)	13–14	20–20½	11–13	5–5½

white. Wings translucent, venation hyaline. Nymph reddish brown, broken white median line on dorsum of thorax. Gills greyish lavender.

Male imago

Head—Yellowish brown. Lateral carina margined with purple. A purplish black spot at inner anterior margin of each compound eye, cephalad of each lateral ocellus. Antenna greyish white, washed faintly with lavender. Compound eyes purplish grey.

Thorax—Pronotum yellowish brown, lateral margins and posterior angles yellow. Mesonotum yellow, the spine, posterior margin, and a small central area near anterior margin dark red-brown. Metanotum yellowish brown, posterior margin dark red-brown. Pleura flesh to cream yellow, marked with lavender at wing roots and above third leg. Ventrally, prosternum white between legs, posteriorly brownish lavender Meso- and metasternum reddish brown washed with purple.

Legs—Fore femur purplish, darker on outer and inner margins and distal end. Tibia purplish brown, basal end cream white. Tarsus white, faintly marked with lavender. Other legs white, tinged faintly with yellowish. Tips of claws and tarsal joinings very faintly purplish grey.

Wings—Translucent, almost semi-opaque in certain lights. Veins faintly yellowish to hyaline. On costal border of forewing, with yellowish tinge. Radius purplish at extreme base, on upper surface. Stigmatic area opaque white. Tendency for some cross veins in this area to fork near costal margin.

Abdomen—Light orange to bronze, the first three or four segments darker and washed with rose. Posterior margins of tergites widely purplish brown, the dark band partially broken at the median line on 1–6. A very faint greyish streak borders the median line on each side. Pleural fold greyish white with faint lavender streak. Ventrally, each sternite bordered narrowly on posterior margin with greyish purple, and central area of each flushed faintly with the same color. Sternite 1 dark

purplish brown. Across the center of sternites 2–7, very indistinct light dots are arranged transversely. Four dots discernible on 1–3, two only on 4–7.

Tails—White, very faintly flushed at base with flesh color to light lavender. Joinings not distinct nor different in color.

Genitalia—Of the 'albomanicata' type. Distal joint of forceps limb shorter than penultimate joint. See Pl. 10, Fig. 14.

Female imago

Similar to the male except as indicated.

Head—Yellowish white. Posterior angles of occiput purplish. Antenna whitish, base of filament slightly lavender.

Thorax—Pronotum greenish yellow. Posterior border and center of anterior margin purple. Mesonotum and metanotum except posterior border, and most of pleura, light greenish yellow. Posterior margins of these sclerites purple. Ventrally, a black transverse bar between the forelegs. Mesonotal spine-like process purplish black.

Legs—Fore tarsus pure white, the joinings and tips of claws purple.

Wings—Longitudinal veins of forewing somewhat more distinct than in male.

Abdomen—Flesh colored rather than orange. First sternite, and central anterior portion of first tergite, purplish brown. Each segment bordered posteriorly as in male. No trace of greyish streak on each side of median line. Pleural fold margined with purple except in anterior third of each segment. Ventrally, an indistinct orange triangle based on the posterior margin of sternites 3–6, extends broadly forward to anterior margin. Whitish ganglionic area evident in each. Sternite 2 purplish in posterior two-thirds. Four dots transversely arranged in center of sternite 2, rather indistinct. Posterior end of each oviduct purplish grey. A dark purple crescent near the point where these enter the common sac. Area over sac purplish rose. Lip of egg valve rose in center, sides grey lavender. Sternites 8 and 9 washed in central area with brownish lavender. Apical margin of 9th sternite as on Pl. 10, Fig. 2. Outer distal angles sharp-pointed, margin between these considerably idented.

Nymph

Deep bronze to reddish brown.

Head—Frontal carina brown. White median streak on vertex and occiput. In one specimen, white on posterior border and outer edge of

compound eyes. Antenna dark brown basally, remainder light yellowish brown, without a dark transverse band.

Thorax—Median line of pronotum narrowly white. A white dot close to median line on each side, at center of pronotum, and toward the lateral margin from these, two crescentic yellowish marks on each side. White dot on each side of median line on mesonotum also, just cephalad of the mesonotal spine. Another white dot, almost in line with the first pair, nearer the wing on each side. Faint whitish spots anterior to the wing roots.

Legs—Dull olive brown, with yellowish marks. Fore femur and tibia dark brown except for lighter fore and hind margins. Tibia narrowly yellow at base, the distal two-thirds yellow. Hairs on foreleg orange. Other legs with yellow bands at each end of the femur and tibia, and a band across the center of the femur. Tarsus as in first leg. Tibial spine and femoral flange of foreleg and claw of third leg, as on Pl. 10, Fig. 13a; and Pl. 11, Fig. 4b.

Abdomen—Median dorsal white line the entire length of the abdomen in some specimens. In others, only the first half or two-thirds of each tergite is white on this line. A whitish dash on each side of this central white line, beginning below the anterior margin and extending outwards and backwards to or beyond the center of the tergite. A white spot on each side, toward center and slightly anterior to the posterior lateral angle. Tergite 10 reddish brown, darker on posterior margin. Ventrally, a whitish line or dash on each side of median line, extending backwards to or beyond the center of each sternite. A dark purplish mark at anterior margin, halfway to pleural fold. Posterior sternites darker red-brown than the anterior ones.

Gills—Greyish lavender, gill tufts lavender. Margins of gills narrowly brown on extreme edge. A whitish area between the brown edge and the lavender central disc. Two rather indistinct brown spots in outer margins of each. See Pl. 11, Fig. 17.

Tails—Dark reddish brown basally. The first darker cross bar rather indistinct.

Holotype—Male imago. Reared from nymph. Pacolet River, near Tryon, N.C., July 15, 1930. No. 1091.1 in C. U. collection.

Allotype—Female imago. Reared from nymph. Same data. No. 1091.2 in C. U. collection.

Paratypes—Male imago, two female imagoes, two female subimagoes. Same location. July 15–17, 1930. No. 1091.3–7 in C. U. collection

Isonychia serrata sp. nov.

MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Male nymph (2 specimens)	14	5		
Female nymph (5 specimens)	14–16	6–8½		
Male imago (1 specimen)	14	22	12	9½
Female imago (1 specimen)	16	19½	14½	7½

Male imago with anterior half of each abdominal tergite light bronze, posterior half purplish brown. Fore femur light at base; fore tarsus light grey-purple. Venation dark purple-brown. Tails very dark brown. Nymph dark red-brown, with light dorsal median streak on head, thorax and abdomen. Gills purplish, two brown dots in outer margin of each.

Male imago

Head—Brown. Black transverse bar below lateral carina. Red-purple spot at each end of keel of median carina, another on outer side of base of antenna. Antenna light grey-lavender. Compound eyes dark grey-lavender.

Thorax—Pronotum brown with purple tinge. Mesonotum yellow-brown. Pleura cream colored with brown and lavender markings. Mesonotum bordered with cream color, and cream colored spot anterior to mesonotal spine. Metanotum and posterior edge of mesonotal spine dark brown. Ventrally dark purple-brown, darkest on metasternum and central sclerite of mesosternum.

Legs—Fore femur grey at each extremity; remainder of femur and all of tibia dark purple. Tarsus lighter grey-purple; distal half of last segment and base of claws as dark as tibia. Other legs whitish, last tarsal joint and claws purplish grey.

Wings—Veins dark purple-brown. Tendency for some of cross veins in stigmatic area to fork toward costal margin.

Abdomen—Bronze with dark purplish brown markings. Anterior half of each tergite bronze, posterior half purplish brown. Wide dark brown posterior border on each, except at median line. Median line light colored, creamy bronze in anterior and slightly darker in posterior of each tergite. A dark brown streak on each side of the light median area in anterior half of each tergite, extending slightly beyond center. These streaks are farther apart posteriorly. Pleural fold and posterior

lateral angle of each side darker than remaining parts of tergite. A small dark spot at anterior margin midway between median line and pleural fold.

Sternite 1 very dark purple-brown except for whitish posterior border. Sternites 2–4 same dark color except for cream colored to light bronze anterior lateral angles, posterior margin, a dash on each side of median line, and four small dots arranged transversely across center of each. Sternites 5 and 6 similar, but light on each side of the dark central area, and but two dots near the center, between the short dashes. 7–9 mostly light, only a restricted dark area in the center. Dashes and dots as in 6. On 2–9, a narrow dark bar parallel to pleural fold, in posterior half of sternite; in line with this bar and anterior to it, a dark dot.

Tails—Very dark brown. Distal third slightly lighter brown. Joinings in basal half lighter brown.

Genitalia—As on Pl. 10, Figs. 19 and 22. Of the 'arida' type. Incurved lower portion of the penes bears 7–8 teeth or spines; 'saw-toothed'.

Female imago

Differs from the male only in these respects.

Head—Bronze, purple between ocelli, at posterior lateral angles of the occiput, and along inner margin of compound eyes. Median and lateral carinae edged with red. Dark spot below lateral carina on each side.

Thorax—Pronotum lighter than in male. Mesonotum yellowish bronze.

Legs—Basal half of fore femur whitish. Second and third legs yellowish, last three tarsal joints washed with purplish grey.

Abdomen—Flushed with pinkish orange, probably due to presence of eggs. Tergites as in male, but dark areas more restricted. Dark areas on sternites restricted to center of each. Median line light. Markings as in male. Sternite 9 with no markings except two short lavender streaks at anterior margin. Apical margin of 9th sternite with little or no indentation. See Pl. 10, Fig. 11.

Nymph

Dark red-brown.

Head—Carina, posterior margin of compound eyes, median line caudad of lateral ocelli, and small areas laterad of each lateral ocellus and cephalad of median ocellus, yellowish white. Antenna dark brown at base. Remainder yellowish brown, except for dark brown transverse band one-third from the base, and a whitish tip.

Thorax—Median line yellowish white, slightly widest on pronotum. On each side of pronotum, three indistinct yellowish marks. Faintly mottled with yellowish, anterior to wing roots. Ventrally, greyish brown.

Legs—Yellow bar at each end of tarsus and across center of femur of foreleg. Each end of fore femur and tibia light brown, remainder of each joint very dark brown. Second and third legs similar, but tibia yellowish at each end, and the yellow bar on the femur one-third from the distal end. Tibial spur and flange of femur of foreleg, and claw of third leg, as on Pl. 10, Fig. 13c; and Pl. 11, Fig. 4c.

Abdomen—Median dorsal line yellowish on first three tergites, light red on others. A blackish irregular line borders the median light streak on each side. Posterior margin narrowly black, and a dark brownish red area occupies most of the area on each side of the central streak, except a lighter portion next to the pleural fold. 10th tergite black except anterior fourth, which is yellowish red.

Ventrally, light red-brown. Median line yellowish in anterior third of sternites 1–7. A dark brown spot in anterior lateral angle of sternites 2–4; a dark brown streak in posterior half of sternites 5–9, paralleling pleural fold. Central portion of sternites 3–8 with yellowish dashes and dots, arranged as in imago.

Gills—Dark purple except for dark brown upper margins and narrow greyish white outer edge. Two brown spots in outer margin. Third gill as on Pl. 11, Fig. 14.

Tails—Marked as in *I. albomanicata*, but very dark red-brown, almost black, basally.

Holotype—Male imago. Reared from nymph—Allen's Creek, near Waynesville, N.C., July 21, 1930. No. 1085.1 in Cornell University collection.

Allotype—Female imago. Reared. Same location. July 23, 1929. No. 1085.2 in C. U. collection.

Isonychia aurea, sp. nov.

MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Female nymph (5 specimens)	16–17	11		
Female imago (2 specimens)	16–17	22–23	13–15½	7

No males of this species were obtained. Abdomen of female imago light orange, with purplish brown markings. Thorax greenish yellow. Fore tarsus not lighter than other joints of the foreleg. Tails dark brown. Venation purplish brown. Nymph dark reddish bronze, gills greyish, each with two brown spots in outer margin.

Female imago

Head—Greenish yellow. Orange yellow on vertex just caudad of ocelli. Posterior border and posterior lateral angles of occiput purplish. Keel of median carina purplish red. Antenna light purplish grey at base, filament same color but darker.

Thorax—Pronotum, mesonotum and metanotum except posterior portions, and pleura, greenish yellow. Pleura marked with purplish grey at wing roots and above third leg. Meso- and metanotal spines, and lateral boundaries of each, dark reddish brown. Ventrally clear light yellow. Brown spot in center and posterior lateral margins of central mesosternal sclerite. White band behind fore legs, similar bands anterior to legs of second and third pairs.

Legs—Fore femur very light brown basally, distal half dark red-brown. Tibia and tarsus very dark brown, slightly washed with purple. Second and third legs greenish yellow. Claws and last three tarsal joints dark purplish grey, joinings slightly darker. First joint faintly purplish grey distally.

Wings—Venation dark purplish brown, the longitudinal veins of the costal border dark yellowish brown. Many of the cross veins of the stigmatic area are anastomosed. Outer margin of hind wing with numerous intercalary and cross veins.

Abdomen—Light orange, brighter dorsally. Tergites marked with purplish brown. A wide band of this color along the posterior margin of each, broken at the median line except for a slender connecting thread along the upper edge. Posterior lateral angles purplish brown. A somewhat crescentic purplish brown mark on each side of the wide light median line on tergites 3–9, its open side toward the median line. A rectangular blotch occupies a corresponding position in tergite 2. These marks arise from a purplish triangular blotch on each side of the median line at the posterior margin, and extend forward beyond the center of the tergite.

Ventrally, a deep orange triangle, its base on the posterior margin and its apex attaining the anterior margin, occupies the middle of sternites 2–6. Within each triangle the ganglionic area appears as a whitish

blotch. Sternites 7–9 yellowish. Posterior edge of egg valve purplish brown. No distinct streak nor dark dot next to pleural fold, on any sternite. Apical margin of sternite 9 shown on Pl. 10, Fig. 12.

Tails—Very dark reddish brown basally, becoming gradually lighter brown in central portion, and purplish grey in the distal fourth. All joinings slightly darker.

Nymph

Body dark reddish bronze.

Head—Frontal carina brownish except for whitish upper central portion. Whitish areas laterad of each lateral ocellus, cephalad of median ocellus, and on anterior and posterior margins of compound eyes. Antenna dark brown at base, the remainder yellow to yellowish brown, with no distinct dark transverse bar.

Thorax—White median line on pronotum, wider anteriorly. Very narrow light median line on mesonotum. Two white marks on each side of pronotum near the anterior margin. Several small light spots anterior to wing roots on mesonotum. Lighter ventrally.

Legs—Yellow, banded with dark brown. Tarsi yellow at each end, narrowly so on fore leg. Distal half of tibia, narrow streak at its basal end, and three bands on each femur yellow. On third leg, the median band of the femur is confined to the hind margin. Tibial spur and flange of foreleg, and claw of third leg, shown on Pl. 10, Fig. 13d and Pl. 11, Fig. 4a.

Hairs of foreleg orange.

Abdomen—Tergites 2–9 each with a white blotch in the anterior portion of the median line, extending to center of tergite on 2–6, but at margin only, on 7–9. A dark mottled dash, crescentic in the anterior tergites, arises from each side of this white blotch, extending outward and backward, but not reaching the posterior margin. A white dot on each side, above and toward the center from the posterior lateral angle. Tergite 10 yellow in basal third; distal two-thirds very dark brown. Ventrally, the anterior margin of each sternite is dark purplish brown, but with a white space at the median line. Indistinct bars and dots are present—a bar on each side of the median line, and at the posterior ends of the bars, four dots transversely arranged.

Gills—Greyish, faintly marked with lavender basally. Mid-trachea and margins, and two spots in outer margin, brown. See Pl. 11, Fig. 12.

Tails—Dark brown at extreme base, then yellowish brown to first dark transverse bar.

Holotype—Female imago. Reared from nymph. Small tributary of Pigeon River, near Hazelwood, N. C., July 26, 1930. No 1090.1 in C. U. collection.

Paratypes—Female subimago and female imago. Reared. Same locality, July 22 and 25, 1929. No. 1090.2–3 in C. U. collection.

GENUS PSEUDOCLOEON Klap 1905

Pseudocloeon dubium Walsh

Nymphs which fit the description given by Dr. McDunnough (Can. Ent. **63:** 85) for this small species were taken from Flat Creek,—a tributary of the Swannanoa River at Black. Mt., N. C.—on June 19, 1930; from Bald Creek,—tributary to the Nolichucky River,—July 6, 1930; and from a tributary of the French Broad River at Selica, on July 13, 1930. No adults were obtained.

The mouthparts of this nymph are quite similar to those of *P. carolina*, differing however in these respects: 1) the canines of the mandibles stand rather erect instead of leaning outward (See Pl. 12, Fig. 17); and 2) the labial palp is plainly composed of three segments, the distal of which is separated by a definite notch on the inner margin from the second segment (see Pl. 12, Fig. 14). Femora with fairly long hairs on the inner margin; tibiae and tarsi with but a few short spines on the outer margin, practically no hairs on the inner margin.

Pseudocloeon carolina Bks.

Rather chunky nymphs, tails not barred, which correspond quite well with Ide's description and figures of *P. carolina* (Can. Ent. **62:** 221, and pl. 18, figs. 3, 3a and 3b), were collected at several stations in the mountain area. Another species, more slender than this one, was however more in evidence during June in the Black Mt. region, from which locality *P. carolina* was originally described. Nymphs of this species were taken from a tributary of the Pigeon River at Waynesville, July 14, 1929; from near Chimney Rock, June 17, 1929; the Rocky Broad River at Lecky Gap, June 23, 1930; the Ocona Lufty River near Cherokee, July 12, 1930; and at Selica, July 13, 1930.

This species differs from others of the genus found in North Carolina in the possession of very long hairs on the inner margin of both femora and tibiae, and somewhat shorter ones on the inner margin of the tarsi. In the specimens from this state, the labial palp is three-jointed, the short

distal joint seeming to be partially fused with the second. Canines of both mandibles lean strongly outward (see Pl. 12, Fig. 13).

A female imago was reared from a nymph of this species captured in the North Fork of the Swannanoa River on June 14, 1930. This female is somewhat lighter than the one described by McDunnough. The thorax is light tan shading into a somewhat darker tan on the metanotum, which is tinged with pale rose. A smoky streak extends forward from the wing roots. Occiput of head and central portion of pronotum faintly smoky. Abdomen cream-colored to light tan, lighter ventrally. Tergites washed faintly with pale rose, the posterior margin of each being deeper rose. Stigmatic areas marked with purplish black. Fore femur, distal end of tibia and fourth tarsal joint smoky brown.

Slender Pseudocloeon nymphs were collected in the vicinity of the Black Mts. These nymphs seem not to be *P. cingulatum* McD. or either of the two preceding species. As no adults were reared, the species cannot be determined at present, but I present the following summary of the characters of the nymphs, referring to them as *Pseudocloeon* sp.?

Pseudocloeon sp?

Size—Body 4–4½ mm.; tails 3 mm.

Body relatively slender, not appreciably widened at the mesothorax, as in *P. carolina.*

Mouthparts. Canines lean outward, but less so than in *P. carolina.* Labial and maxillary palps much as in *P. carolina.* See Pl. 12, Figs. 28 and 32.

Legs—Fairly long hairs on hind margin of femur; a few short spines on tibia and tarsus, longer than in *P. dubium*; no hairs as in *P. carolina.* Olive-brown except at each end and a narrow line on the hind margin of the femur; basal half (in some specimens, oblique band only) of tibia; basal half of tarsus, except narrow dark line at basal joining.

Abdomen dorsally dark reddish brown with definite olive tinge. Tergites 4, 5 and 9 lighter. Dark mark on each side of median line anteriorly on 2–6, ending at center of tergite with a brown dot. Similar dark dots on 7–9. Sternites light tan to yellowish brown, washed with brown laterally. Tails light yellowish brown, not banded.

Taken from the Rocky Broad River on June 23, 1930. Nymphs which appear to be of the same species were also found in the Catawba River above Marion, June 16, 1930.

GENUS CENTROPTILUM Eaton 1869

Centroptilum album McD.?

A single specimen of this genus,—a female imago—was captured at the auto headlights from the North Fork of the Swannanoa River on the evening of July 3, 1930. This specimen is smaller than any species recorded from the United States or Canada. It comes nearest to the description of the female of *C. album* McD. (Can. Ent. **58**: 189), although the latter is a somewhat larger species. To this species I doubtfully refer my specimen, and give a description of it, for purposes of comparison.

Size—Body 3 mm.; wings 3½ mm.; tails 3½ mm.

Head light brown. Ocelli ringed at base with purplish black. Basal segments of antenna whitish, the filament purplish in basal half, white distally.

Thorax—Light brown, faintly washed with rose. Rose markings on lateral and postero-lateral margins of pronotum; on mesonotal median line posteriorly; laterad of the base of each middle leg, on the mesosternum; anterior to the wing roots; above and on the third coxa. Mesonotal spine white. Prominent spinous process at center of metanotum. Legs white. Claws and last tarsal segment tinged with brown.

Wings—Hyaline. Intercalaries single, as usual. Hind wing very narrow, two longitudinal veins. Costal angulation not particularly prominent.

Abdomen—White with yellowish tinge, prominently marked with deep wine-red. Tergite 6 mainly wine-red; 7, 9 and 10 yellowish brown with rose tinge. Wine-red patches at center of tergite 2, and occupying most of the lateral areas of 2 and 3. Small triangular lighter red spots on anterior margins of 4 and 5, one on each side. Tiny black mark at spiracular area. Ventrally white, the three posterior sternites washed with yellow. Posterior margin of each sternite with prominent wine-red border, except on median line. Spots of same color near lateral margin of each. On 2 and 6, a dark line parallels the pleural fold.

Tails white.

GENUS BAETIS Leach 1815

Although nymphs of this genus were relatively abundant in all three regions of the state, only a few species were reared. Of these, and of the female imagoes caught in flight or entangled in spiders' webs near the streams, very few could be positively identified.

Baetis rusticans McD.?

Nymphs taken from Flat Creek near Black Mt. transformed on June 15, 1930. The imagoes seem to correspond quite closely to the above species, in which I am placing them tentatively.

Baetis australis, sp. nov.

MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Male imago (1 specimen)	4½	Broken	4½	4
Male subimago (5 specimens)	5	8	4–4½	1½–2
Female imago (1 specimen)	4½	Broken	5	1¼
Female subimago (3 specimens)	4–5	6½	4½–5	1

This species is close to *B. frondalis* McD., differing from it in the following particulars. 1) no spine at the base of the excavation of the posterior margin of the 9th segment; 2) inner apical margin of first segment of forceps with tuberculate process; 3) no short spinous process on outer basal portion of third segment of forceps; and 4) a slight difference in the venation of the hind wing.

Male imago

Head—Turbinate eyes large, orange; oval in outline. Antennae light purplish brown.

Thorax—Dark ruddy brown; intersegmental areas of pleura yellowish. Anterior portion of mesosternum lighter yellowish brown.

Wings—No cross veins before bulla in forewing. 6–8 cross veins beyond the bulla, not anastomosing. Only the most apical two of these touch the subcosta. Stigmatic area somewhat opaque. No marginal intercalaries in first interspace. Hind wing long and narrow, the costal angulation reduced. See Pl. 12, Fig. 4.

Legs—Yellowish white.

Abdomen—Abdominal tergites 1–6 translucent silvery white in central area, the lateral area of each being purplish brown. Posterior margins narrowly purplish brown. Tergites 7–10 opaque reddish brown with purple tinge. Prominent continuous purplish black line on stigmatic areas. Ventrally, translucent greyish white, sternite 1 shaded with brown. Tails missing from the single specimen.

Genitalia as on Pl. 12, Fig. 3.

Male subimago

Very similar to imago, but rather paler. Wings grey.

Female imago

Head—Purplish rose.

Thorax—Yellowish brown. Pronotum marked with rose.

Abdomen—White central area on abdominal tergites 1–6 present, but tinged with rose. Abdomen purplish rose dorsally; black stigmatic marks as in male. Ventrally, silvery with faint rose tinge. Purplish rose streak on each sternite next to the pleural fold, wider on anterior sternites. Tails missing. Apical margin of extension of 9th sternite as on Pl. 12, Fig. 19.

Female sub-imago

Rather similar to imago, but with white markings on head and thorax, and the central light area on abdominal tergites 1–6 entirely obscured by reddish brown tinged with purple.

Holotype—Male imago. Goshen Swamp, N. C. Taken by Prof. Needham, on April 11, 1929. No. 1098.1 in C. U. collection.

Allotype—Female imago. Lenoir Co., same date, same collector. No. 1098.2 in C. U. collection.

Paratypes—4 male subimagoes, 3 female subimagoes. Same as holotype. Burncoat Swamp, same date and collector. No. 1098.3–9 in C. U. collection.

These specimens were secured by Prof. Needham from the coastal plain region in the localities listed above, on April 11, 1929. Along with these were several female imagoes somewhat smaller in size and more definitely tinged with rose, which I am not including in the above species. Likewise several nymphs were collected from the same stations, but it is not known that they are associated with the adults. These nymphs are long and slender, show a black stigmatic line as in the imago of *B. australis,* and the abdomen seems disproportionately long in its relation to head and thorax combined.

Baetis sp? No. 1

A single male imago taken from Flat Creek, near Black Mt., on June 19, 1930, is apparently close to *B. incertans* McD., but differs from it in

the following respects: 1) no ruddy tinge on pleura; 2) abdominal tergites whitish on posterior margin, instead of deeper ruddy brown; 3) abdominal tergites 7–10 deep orange-brown; 4) no smoky apical spot on fore tibia; 5) hind wing with an extra short intercalary between the two strong ones and the second vein. Genitalia as on Pl. 12, Fig. 9.

GENUS CALLIBAETIS Etn. 1881

Callibaetis sp?

Nearly one hundred nymphs of one species of this genus were found in a tiny temporary pool in the vicinity of Greensboro, on March 18, 1930. Although seemingly in good condition, not one of these transformed to the subimago state, although many died in the attempt to do so. By April 6 most of the nymphs had died. As none was reared, no attempt will be made to determine the species, unless a future comparative study of many species of nymphs of this genus can be undertaken.

Only this single species was found in the collecting done in the state.

GENUS ACENTRELLA Bengtsson 1912

Dr. McDunnough prefers to retain in the genus Baetis the four species *B. propinquus*, *B. frivolus*, *B. insignificans* and *B. dardanus*, the latter being perhaps synonymous with *B. propinquus* (see Canad. Ent. **57**: 172 and 175). The lack of a costal projection on the hind wing, which would place these in the genus Acentrella, he thinks is not a character of generic value. Since, however, the genitalia of the last three species mentioned likewise differ somewhat from the usual Baetis type, I feel that there is sufficient justification for recognizing Acentrella as a valid genus. Especially is this true, since the two-tailed nymph of Acentrella is readily distinguishable from all species of Baetis except the western *B. bicaudatus*. It may be distinguished from the nymph of Pseudocloeon, which also has but two tails, by the presence of the second pair of wing buds.

A species of this genus, rather close to *B. frivolus* but differing from it and from all the other three species mentioned above, is present in my collections from Big Alamance Creek in the piedmont area of the state. Acentrella nymphs, which appear to be of this same species, were taken also from the outlet of Hamburg Lake and from the Uharie River, but were not reared. One male subimago, one male imago and one female imago were reared from the Alamance nymphs. This species I designate as follows.

Acentrella ampla, sp. nov.

MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Male nymph (2 specimens)	6½–7½	5–6		
Female nymph (6 specimens)	7–8½	4½–6		
Male imago	7	Broken	6½	Broken
Female imago	8½	12	6½	3½

Nymph

Mature nymph dark red-brown dorsally, lighter ventrally. Immature nymph very light red-brown. (Mature nymph used for description.)

Head—Brown. Vertex and occiput mottled; median line yellow. Lateral ocelli large, rounded. Median ocellus small, somewhat crescentic. Antennae light brown basally, distal portion yellowish. Mouthparts very similar to those of Pseudocloeon.

Thorax—Dark red-brown dorsally, marked and mottled with yellow. Ventrally, dark brown anterior to second and third legs, and brown band laterad of second leg. Remainder yellow.

Legs—Yellow, marked with brown. Greyish brown marks on femur toward distal end. Joinings dark brown. Distal end of tarsus, and claw, very dark brown.

Abdomen—Dorsally, tergites 1–9 dark red-brown, each with a round yellow dot on each side of median line at center. Tergite 10 yellow. Ventrally, light red-brown, the posterior margin of each sternite darker. On 2–8, two light marks, one beneath the other, on each side of median line. Sternite 1 with but one round mark on each side of median line; 9 and 10 unmarked.

Gills—Simple. Very similar to Baetis. Opaque white; anterior and inner posterior margin of each narrowly brown.

Tails—Two. Very short unsegmented rudiment of middle tail present. Hairs on inner margin only; tips bare. No dark markings.

Male imago

Head—Turbinate eyes orange. Somewhat rounded in outline as viewed from above. Not contiguous over occiput. Lower portion of eyes, and mark across frons, black. Antennae light brown.

Thorax—Light red-brown. Mesonotum marked with longitudinal

dark brown streaks on median line and on each side of this. Red tinge most prominent on metanotum. Pleura red-brown, sternites light red-brown.

Legs—Foreleg missing. Second and third legs yellowish.

Wings—Hyaline, Veins definitely yellowish brown. 7–8 costal cross veins beyond the bulla; only a slight tendency for these to anastomose. Paired intercalaries absent from first interspace, well developed in others. Hind wing long and narrow; two distinct and well developed longitudinal veins.

Abdomen—Segments 1–5 yellowish brown with tinge of grey. 6–10 light reddish brown. Posterior margin of each widely opaque white. Tergite 1 mostly concealed by wide metanotum.

Genitalia—Distal segment of forceps limb longer proportionately even than in *B. frivolus*, which the genitalia most resemble. See Pl. 12, Fig. 21.

Tails—Missing.

Female imago

Differs from male as indicated.

Head and thorax cream-yellow, the latter marked with dark brown. No dark longitudinal stripes on mesonotum, as in male.

Legs—Yellow, the joinings narrowly brown.

Wings—As in male, but a faint oblique intercalary between the two longitudinal veins of the hind wing. See Pl., 12, Fig. 11.

Abdomen—Much as in male, but segments 1–6 tinged with light orange, due to the presence of eggs, Segments 7–10 olive rather than reddish brown. A rose-colored spot at center of distal margin of tergite 10, and a narrow transverse rose line next to white posterior border on tergites 2–5. Distal margin of sternite 9, and plates of 10th sternite, shown on Pl. 12, Fig. 20.

Tails–Yellowish white.

Holotype—Male imago. Reared. Big Alamance Creek, N. C., March 21, 1929. No. 1099.1 in Cornell University collection.

Allotype—Female imago. Reared. Big Alamance Creek, Feb. 20, 1930. No. 1099.2 in C. U. collection.

Paratypes—Male subimago, and two nymphs. Same location, Feb. 20 and 25, 1930. No. 1099.3–5 in C. U. collection.

DEPARTMENT OF ENTOMOLOGY,
CORNELL UNIVERSITY, ITHACA, N. Y.

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THE ABUNDANCE OF THE DOLPHIN, CORYPHAENA HIPPURUS, ON THE NORTH CAROLINA COAST

By E. W. Gudger

Bibliographer and Associate, American Museum of Natural History

Plate 13 and Two Figures

The large dolphin, *Coryphaena hippurus*, has been thought to be a rare fish on the North Carolina coast, apparently because no one has looked for it at the place where it could be found in relative abundance. But, as this article will show, it is to be found in considerable numbers when sought for near the edge of the Gulf Stream off Cape Hatteras.

During ten summers' work at the Biological Laboratory of the U. S. Bureau of Fisheries at Beaufort I saw but one specimen—a 28.5-inch fish sent in by Mr. Charles S. Wallace of Morehead City on August 1, 1902. Smith records another fish taken near Beaufort in 1903, and notes that there are two small specimens (about 15 inches long) from Carteret County in the State Museum at Raleigh. In addition three specimens of the smaller dolphin 20 to 24 inches long, were taken, according to the same authority, by the U. S. Fisheries steamer Fish-Hawk, about 28 miles off Cape Lookout on August 21, 1902. A few others were taken off shore by the "Fish-Hawk" in 1912 or 1913. So far as I know, these few specimens are the only ones of the dolphin, *Coryphaena*, recorded from the North Carolina coast.

Thus matters stood until I saw in the issue of the Raleigh (N. C.) *News and Observer* for October 8, 1931, a picture of 14 dolphin, part of a catch made the day previous by three anglers in the vicinity of Diamond Shoals, the "graveyard of the Atlantic" off Cape Hatteras. One of the successful anglers was Mr. Frank Kugler of Washington, N. C., who kindly sent me the negative from which the figure herein (not the one referred to above) was made, and who gave me valuable data about the catching of these fish.

The photograph reproduced herein (Plate 13) shows 27 dolphin hanging on a rack on the dock, while on the floor are four or five more. On this one trip Mr. Kugler and two friends caught 48 of these fish heretofore thought very scarce. These were taken about 10 or 12 miles due

east of Cape Hatteras Lighthouse, between Diamond Shoals (the "Outer Diamonds," eight miles off shore) and the Diamond Light-ship which is about four miles further out. They were all caught trolling with rod and reel and of their behavior when hooked Mr. Kugler writes:

The dolphin is a very swift swimmer and is a wonderful fish to catch, making a very quick and hard strike, then going into the air for about ten or twelve jumps, each something like two or three feet high. Its coloring is particularly beautiful, seeming like all the colors of the rainbow as it pulls and surges at the hook. The coloring then turns from a pale lemon to a golden green, then to blue with silver tints. The color changes continuously with the efforts of the fish to free itself from the hook. When one is hooked quite a number will follow it to within a short distance of the boat.

Their presence in such numbers off Diamond Shoals is accounted for as follows.

Mr. Kugler notes that the dolphin at Cape Hatteras feed on flying fishes. Scaring these into flight in small schools and following them closely, the dolphin are always ready for them when they fall into the water. The presence of flying-fishes at Cape Hatteras is in turn accounted for as follows by Mr. C. M. Breder, Jr., of the New York Aquarium.

In rounding the Cape on a trip to Panama some years ago, he noticed that the blue Gulf Stream and the green littoral waters are almost separated by a line, certainly the transition is to be found in the length of the ship. In such a tide rip as this, at other times and places, great numbers of small crustaceans have been taken. And in this narrow transition zone off Cape Hatteras, it is reasonable to believe that a great concentration of this crustacean food stuff is found. It is known that these invertebrates constitute the chief food of the flying fishes.

On the trip referred to Mr. Breder made careful counts of the flying fishes which were started up by the vessel in her course south. His records were later plotted and the greatest density of flying fishes was found to be slightly south of Cape Hatteras. This is presumably the region of greatest density of their food and likewise of the dolphin whose food they in turn are. Breder's figure is reproduced herein (Figure 1).

His figure shows graphically what was found but it will be well to quote what Breder has to say in fuller explanation than is given in the caption. He writes thus:—

It will be noted that the greatest concentration [of flying fishes] is east of the axis of the Gulf Stream, that the greatest concentration is

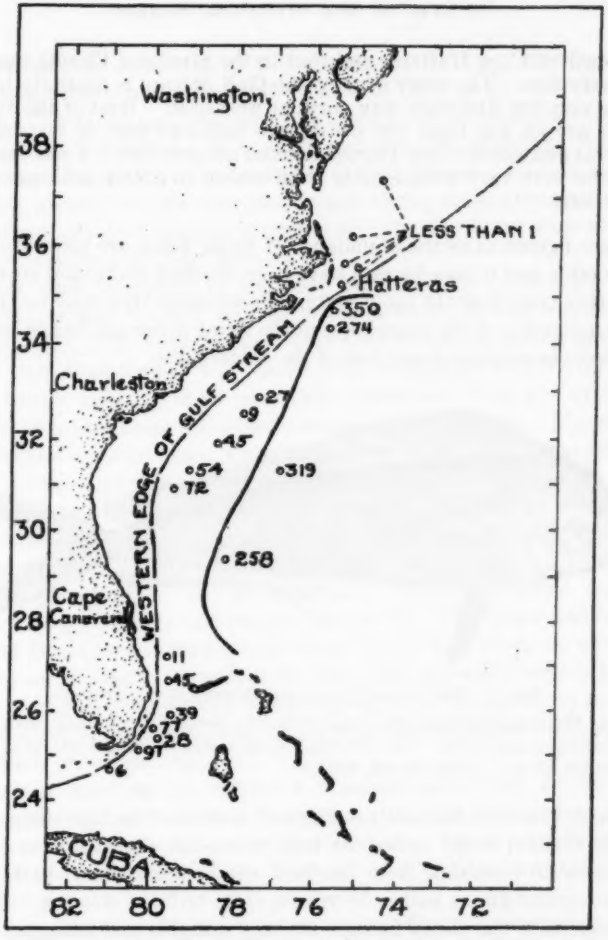

FIG. 1. CHART TO SHOW DISTRIBUTION OF FLYING-FISHES (AND BY IMPLICATION OF DOLPHINS ALSO) FROM CAPE HATTERAS TO THE SOUTHERN END OF FLORIDA

The data are for the calculated population of flying-fishes in the Gulf Stream, September 26 to August 13, 1928. The figures given at each station are the nearest whole numbers of fishes per square nautical mile. The heavy solid line separates the areas with a population of over 250 fishes per square mile from those under 100. The line in its northeast trend approximates the axis of the Gulf Stream. Past the western edge of the Gulf stream none were counted during periods of observation. Consequently these are calculated as less than one per square mile. (After Breder, 1929.)

just south of Cape Hatteras and that in the Straits of Florida there are relatively few. The inner edge of the Gulf Stream is similarly barren, that is very few find their way north or west of it. West of the axis the counts are all less than 100 per square mile and east of it (south of Hatteras and north of the Florida Straits) all over 100. These numbers of course may vary considerably from season to season with prevailing winds, etc.

These figures as to the abundance of flying fishes are interesting and remarkable and it may be said have been checked and found correct on two other trips over the same route. Presumably they may be taken as a fair indication of the abundance of the flying fishes and hence are indicators of the relative abundance of the dolphin also.

FIG. 2. THE LARGE DOLPHIN, CORYPHAENA HIPPURUS

Note the steep forehead, the long mane-like dorsal fin extending nearly to the deeply-forked caudal fin. The forehead in old males becomes vertical as may be seen in the plate. (After Smith, 1907.)

The dolphin is a fish easily recognized because of its high steep profile, nearly vertical in old males, its high mane-like dorsal fin (to be seen in Figure 2) extending from the back of the head almost to its deeply forked caudal fin, as well as by reason of its brilliant coloring. Because the counts of the dorsal fin rays are very variable and with very indefinite limits for the so-called species, and because of the varying length and shape of the head and its parts with age and sex, many species of dolphins have been described. However, these by most authorities have been reduced to two species, *Coryphaena hippurus* and *C. equisetis*, and the tendency today is to consider the latter as a young or immature form of the former.

However, still speaking, generally, Cape Hatteras would seem to be about the northern limit for schools of the large dolphin and this conjec-

ture is markedly confirmed by Breder's chart. It is not recorded from Chesapeake Bay, but occasional specimens drift north with the Gulf Stream. Thus Smith (1907) notes that he has taken small specimens as far north as Cape Cod. It is taken occasionally off Sandy Hook in August and September. In September, 1921, Breder collected a small specimen about 15 inches long just outside Sandy Hook Lightship. He has a record of a four-foot specimen taken in October of the same year off the southwest end of Long Island.

I have been interested to find that Mr. Kugler's catches at Cape Hatteras are not the first specimens taken with rod and reel in this locality. Mr. F. L. Fuller of New York City writes me that in the summer of 1929 he and a party of friends took six dolphin with rod and reel about fifteen miles off shore near Cape Hatteras. This was probably the first time that these fish were so taken in these waters. The largest fish weighed only six pounds but larger ones were seen in the schools found. Later in the same year one of Mr. Fuller's party took a 21.5-pound specimen about 15 miles off shore while trolling from Cape Lookout to Ocracoke Inlet, and in October 1931, Mr. Fuller took two small dolphin while trolling over this same course.

The explanation of Mr. Fuller's small catches compared to Mr. Kugler's large ones is to be found in the fact that the former was fishing south of Hatteras and further that since he was only about 15 miles off shore he was too far to the west of the heavy line in Breder's figure (Fig. 1) which separates the areas of dense population of flying fishes (and of dolphins) to the east from that to the west having a relatively scanty population per square mile.

Generally speaking the dolphin is a pelagic fish, found in the open ocean in the warmer regions of the world. In such waters it is cosmopolitan, and is common but hardly abundant. Possibly nowhere else is it so concentrated as off Cape Hatteras—the explanation being that set out above.

The large dolphin (*C. hippurus*) is said by Goode and Bean in their "Oceanic Ichthyology" to reach a length of 6 feet. Mr. Kugler's largest specimen was not measured but it weighed 23 pounds. He saw fish which he believed to be larger but did not happen to take any.

In tropical waters where its food is very abundant the dolphin undoubtedly reaches its maximum size. Our largest records here are from Tahitian waters where one weighing 55 lbs. was taken with rod and reel in 1931 by Eastham Guild. However, the largest taken by rod and reel, and indeed the largest taken in any way (so far as our records go), was

one of 63 lbs. caught near Papeete by Zane Grey in 1930. Unfortunately no dimensions were given for either of these heavy fish, but the photographs show them to have been huge specimens.

In turn the smallest Coryphaenas on record are Lütken's specimens ranging from 18 to 62 mm. (0.7 to 2.85 inches) in two series—one for each of the common species. Others but slightly larger are 36 young specimens ranging from 23 to 75 mm. (0.9 to 3 in.) reported from Chame Point, Pacific coast of Panama, by Meek and Hildebrand in 1925.

Nothing is known as to the breeding habits and embryology of the dolphin. Beebe and Tee-Van (1928) report the capture on March 23, 1927, of a five-pound female whose ovaries measured 175 by 30 mm. and weighed 96 grams. The number of eggs was estimated at 500,000. Of these about one third measured 0.85 mm. in diameter, the others from 0.17 to 0.28 mm. in diameter. From the facts that the fish is pelagic and the eggs so small, it is conjectured that they are probably extruded directly into the water, are fertilized and presumably undergo their development while floating at the surface of the ocean. So far as I know no specimen smaller than Lütken's 18 mm. (0.7 in.) fish has ever been taken. Lütken's studies, however, show that the little fishes undergo considerable changes, especially in the head region, as they grow older.

These differences in the shape of the head even in older fish are admirably shown in the specimens portrayed in the plate. Indeed one particular reason for publishing this plate in its large size is that these changes in the form of the head may be shown. Specimen no. 5 from the left is evidently an old male. The photographs of Guild's and of Zane Grey's huge Tahitian fish show the same almost vertical forehead.

To sum up the whole matter—The dolphin is a pelagic fish, an inhabitant of the open ocean. It is a predatory fish, and its favorite food is the flying fishes. Dolphins and flying fishes both come north with the Gulf Stream. The projection of Cape Hatteras serves to throw off to the east the south-flowing littoral water. In the vicinity of Diamond Shoals there is seemingly a marked concentration of the crustacean food on which flying fishes feed. This leads to a considerable gathering of flying fishes and as a result of dolphins also off Cape Hatteras. And now that this is known, it may be expected that anglers will resort to these banks in considerable numbers for the sport to be had in catching the dolphins.

Unfortunately, the dolphin does not seem to be much used for food, possibly because it is not taken in sufficient numbers to interest the commercial fishermen. Smith says that it "is a good food fish, although

reputed to be poisonous at times." Beebe and Tee-Van found it for sale in Port-au-Prince about once a week. However, it was not highly valued and was sold at a low price. Mr. Kugler in turn, writes that "It is not much good as a food fish, though edible." I regret that I have never had an opportunity to make a personal test of its edibility.

With regard to its alleged poisonous properties, it may be said that many tropical marine fishes are poisonous at certain seasons of the year. During the breeding season, their ovaries secrete poisonous substances which permeate the surrounding tissues. The universal method of testing whether or not the flesh of the dolphin (and other fishes also) is poisonous, is to put a piece of silver in the vessel with the flesh during the cooking. If this silver turns black, the flesh is regarded as poisonous.

The name dolphin is an unfortunate one for this fish owing to the fact that since ancient times this name has been the peculiar property of the small whales or porpoises (mammals not fishes) about which classical writers have written so interestingly. The generic name, *Coryphaena*, goes back to Aristotle. It's root is the Greek Koryphe, a head; Korys, a helmet—presumably in reference to the very steep forehead. The specific appelations *hippurus* and *equisetis* both mean horsetail and refer to the mane-like dorsal fin very similar to the horse-hair plume found on Grecian and even on some modern helmets. How correctly these names apply may be seen by reference to Fig. 2, in which this plume-like dorsal fin is shown. The fishes have been called dorados by the Spaniards because of their predominant golden color. Much has been written about the changing colors of the dying dolphin. As Mr. Kugler has noted, its colors do change in its dying struggle but somewhat similar color changes occur at death in most bright-hued tropical fishes.

The catches noted herein resulting from seeking the dolphin where it is found, may be expected when they become known to send anglers to Cape Hatteras seeking this sport. The data contained herein and the facts set forth as to its value as an angler's fish parallel the similar data which I published (1931) for another reputedly scarce fish, the triple-tail, in the coastal waters of North Carolina.

The data set forth in this earlier article has resulted in the search on the part of anglers for the triple-tail in its haunts. In the same way it is hoped that the publication of this present article will lead to the further taking of the dolphin by anglers and to an extension of our knowledge of its range and habits.

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PLATE 13

PART (27) OF A CATCH OF 48 DOLPHIN MADE BY MR. FRANK KUGLER AND PARTY OFF CAPE HATTERAS, OCTOBER 7, 1931

Note the almost vertical foreheads of fish numbers 3 and 5 of the top row counting from the left. These are undoubtedly old males. The fish with more pointed heads are females if large, but are immature males if small. (From a photograph by F. C. Kugler.)

PLATE 13

RHIZOPHIDIUM, PHLYCTOCHYTRIUM AND PHLYCTIDIUM IN THE UNITED STATES

By JOHN N. COUCH

PLATES 14–17

RHIZOPHIDIUM

The genus *Rhizophidium* includes about thirty species which live in the water mostly as parasites on algae, though some live on other fungi, lower animals, or even pollen grains, and one species, *R. xylophilum*, grows on decaying twigs in water. The genus is characterized by the fact that the sporangia are extramatrical and sessile on the host cell, getting food by means of intramatrical rhizoids. A few species have been described, however, in which the sporangium develops between the host wall and the cytoplasmic membrane of the host. The sporangia, when mature, give rise to small uniciliated zoospores. The zoospores are spherical or slightly elongated and each one possesses a small glistening globule. In *R. globosum* and *R. acuforme* I have found spores of two distinct sizes. It would be interesting to determine if this difference in size is associated with a difference in function. They move about with a quick jumping or darting motion, the cilium being directed backwards. The spores eventually come to rest on or near the host, germinate, sending a fine thread down into the host cell. This thread gives rise to the rhizoids; the spore, to a new sporangium. In some species resting spores are formed as well as sporangia. These resting spores may, in some species, be accompanied by a smaller cell which functions much like an antheridium.

The genus is closely related to *Phlyctochytrium*, being separated from it only on the basis of the presence of a subsporangial vesicle in *Phlyctochytrium* and the absence of such a vesicle in *Rhizophidium*. In *Phlyctochytrium Schenkii* this vesicle is very large and distinct while in *P. Hallii* the vesicle, while usually distinct, may sometimes be absent. In *Rhizophidium globosum* there may sometimes be a faint sign of a vesicle. Thus through *P. Hallii* and *R. globosum* the two genera shade imperceptibly into each other. It is better, for the sake of convenience, to retain the two genera and to deal as best we can with the intergrading forms.

The genus is also related to *Phlyctidium*, being separated from that on the basis of the absence of rhizoids in the latter.

The following species of *Rhizophidium* have been reported in the United States and I am adding four to the list:

Rhizophidium polysiphoniae (Cohn) Petersen—reported by Martin (1922), New Jersey.
Rhizophidium carpophilum Zopf—reported by Coker (1923), Chapel Hill, N. C.
Rhizophidium pollinis (A. Braun) Zopf (certainly not true *R. pollinis*)—reported by Melhus (1914), Madison, Wisconsin.
Rhizophidium globosum (A. Braun) Schroeter—reported by Atkinson (1894), Ithaca, N. Y.
Rhizophidium minutum Atkinson—reported by Atkinson (1909), Ithaca, N. Y.
Rhizophidium sphaerocarpum (Zopf) Fischer—reported by Atkinson (1909), Ithaca, N. Y.
Rhizophidium cordicola Zeller (*marine*)—reported by Zeller (1918), Oregon.
Rhizophidium pollinis (A. Br.) Zopf—reported herein (1932), Chapel Hill, N. C.
Rhizophidium acuforme (Zopf) Fischer—reported herein (1932), Chapel Hill, N. C.
Rhizophidium mamillatum (A. Br.) Fischer—reported herein (1932), Chapel Hill, N. C.
Rhizophidium minimum (Schroeter) Fischer—reported herein (1932), Chapel Hill, N. C.

Rhizophidium globosum (A. Braun) Schroeter

Sporangia sessile, one to many on the host cell, spherical with a smooth colorless membrane of variable thickness; at times so thin that it collapses after the spores have emerged, sometimes up to 2μ thick; sporangia 18–30μ thick; with one or several primary rootlets, which branch out in the host cell into an elaborate net work of fine threads to form the mycelium. Spores emerging slowly through one or several (3) openings, with one long cilium directed backwards as they emerge; with a conspicuous oil droplet; 2–4.8μ thick. Resting spores (oogonia?) common; often formed on the same cell with sporangia; always (?) accompanied by a small cell which appears to function as an antheridial cell, the latter becoming entirely empty during the development of the resting cell; spherical, with a thick smooth membrane and a large oil globule; 10–14μ thick. Germination not observed.

On *Spirogyra areolata* Lagerh., *Spirogyra* sp., and *Mougeotia* sp., collected April 1922 and several times since. Though looked for during

the summer and fall this species has been collected only during the spring. Reported by Atkinson on *Spirogyra* sp., Ithaca, N. Y., 1894.

The form which I have taken to be this species differs from typical European material as understood by Schroeter and Minden in several ways. Minden (1911) states that the rhizoids are very difficult to see, while in the Chapel Hill form the rhizoids are very conspicuous. He gives the spore size as 2–2.5μ thick, whereas the spores in the present form are 2.4–4.8μ thick. The resting spores in the European material are over twice as thick: 25–30μ as against 10–14μ thick in the Chapel Hill form. Moreover, neither Schroeter nor Minden mentions the small cell which accompanies the resting bodies and they describe the wall of the latter as being minutely spiny while I have observed only a smooth membrane. These discrepancies seem rather wide but because of the large numbers of species of *Rhizophidium* already described and the lack of enough of the much desired information concerning the limits of variability in the species of this genus it seems best not to increase the number of species except for most obvious reasons.

The infecting spore usually comes to rest on the *Spirogyra*, loses its cilium and sends in a fine thread through the wall. It sometimes happens, however, that spores which come to rest some distance from their prospective host may also penetrate the *Spirogyra* cell. In such cases it often appears that the cilium itself (fig. 5) may have come in contact with the wall of *Spirogyra* and penetrated it. I have also noticed a number of spores which had germinated in the water comparatively far removed from the *Spirogyra* threads. Such spores presented the appearance of spores with branched cilia. I have been unable as yet to determine the origin of such a structure as that shown in (fig. 4). Whether the spores in the process of germination always come to rest, lose or withdraw their cilia, and then send out a germ tube, or in some cases the cilia are transformed into the infecting mycelium can only be proved by further study. I once kept a group of eleven spores which had come to rest with cilia attached under observation for over an hour. During this time, the spores remained motionless except for a little amoeboid movement. At the end of the hour the cilia were still attached, all having the distinct appearance of hollow tubes. All the cilia were of about the same length and none showed any branching.

In this connection it is interesting to recall the observation of Gobi (1899) on the behavior of the cilium in *Harpochytrium hyalothecae* Lagerheim (*Fulminaria mucophila* Gobi). This parasite occurs on a filamentous desmid which is encased in a thick gelatinous sheath (*Hyalo-*

theca dissiliens). Gobi claims that the spore thrusts the cilium down through the gelatinous sheath and that the cilium becomes the rhizoid which attaches the spore to the cell wall of the desmid. Atkinson ('03), however, does not agree with Gobi.

It appears to be rather unusual for any of the spores of parasitic chytrids to germinate when not in contact with the host. I have seen only one other example of such behavior (to be published later). De Bary (1864) also describes such behavior for the spores of *Rhizophlyctis rosea* (Woronin and de Bary). This fungus, however, was growing as a saprophyte on the surface of old, very damp, flower pots.

It is very interesting to observe, under a high powered lens, the reaction of the host protoplast to the invading rhizoids of the parasite. If the infection is severe, i.e. if a number of spores penetrate at one spot (fig. 9), the host cytoplasm sets up a violently streaming motion, the cytoplasm surging toward and away from the infected area. Such behavior suggests that the host cytoplasm is putting up a violent fight against the rhizoids of the parasite. Sometimes, due perhaps to the unfavorable reaction of the host, the rhizoids of the parasite may fail to develop normally (fig. 10). Some of these rotating streams of cytoplasm connect the pyrenoids with the infected area, a fact of considerable significance since, as a rule, the pyrenoids are destroyed and the starch hydrolysed by the parasite. As the parasite develops the chloroplast of the host is often pulled toward the region of infection (fig. 10). A single parasite on a host cell may be enough to completely exhaust the starch and cause the collapse of the cytoplasmic membrane. A single cell may support a large number of parasites but in such an event they are rather dwarfed in size. The parasite may infect either the vegetative or the cells which are about to engage in sexual reproduction. I have noticed, however, that infection is much more abundant while the *Spirogyra* is undergoing sexual reproduction and that the cells most frequently infected are the reproductive cells. This fact, however, is not brought out in the plate.

The mature zoospore contains a single, conspicuous, glistening globule of food (?) material. This single globule remains distinct in the spore even for some time after infection but as the spore increases in size these globules increase in number, there being some small ones and some comparatively large ones. At first the globules are located near the base of the sporangium (figs. 1, 2) but later they become distributed throughout the cytoplasm (figs. 12, 13).

When the sporangium has attained its mature size, the contents

suddenly undergo a striking change. The globules disappear and the cytoplasm becomes more or less homogeneous in appearance. Following rapidly after this homogeneous stage the cytoplasm shows vast numbers of very minute dots or globules which are fairly evenly distributed through the cytoplasm. These smaller globules flow together to form larger globules until finally the globules which occur one in each spore are formed (figs. 13–15). Lines of cleavage then block out the spores. From observations on living material only, I have been unable to determine if the spores are blocked out by simultaneous or progressive cleavage. The spores once blocked out appear, as nearly as I could determine, to remain distinct until their final discharge, there being no disappearance stage as in the sporangia of the *Saprolegniaceae*. Immediately after the appearance of the spore origins one or several thin places, the pores of emergence, appear in the sporangial wall. In small sporangia only one thin place appears while in large sporangia as many as five may develop. The internal pressure of the spore mass pushes against these thin spots so that the wall bulges out forming blunt papillae (fig. 15).

This pressure finally causes the sporangial wall to give way and the spores then emerge slowly one by one. As a rule all of the pores in a sporangium open so that spores may be emerging from such sporangia through all of the pores simultaneously. The spores creep through the pores in a somewhat amoeboid fashion, the cilium being dragged on behind. Atkinson (1894) has given some very interesting observations on spore discharge in this species. After emerging the spores do not swim away instantly but remain for a brief moment near the mouth, motionless except for a faint trembling movement. Then suddenly the spore darts away. It swims through the water with a very erratic jumping motion. Sometimes, however, a spore may swim for a considerable distance in a more or less direct course. During the swimming the cilium is directed backwards.

In addition to the asexual propagation there is also a stage, which, to all appearances, seems to be sexual reproduction. A spore comes to rest on the host, penetrates the wall, and develops apparently just like a sporangium. Later another spore comes and attaches itself to the larger body (figs. 7, 8). Because of the subsequent behavior of these two bodies it would seem correct at this stage to designate the larger body as the oogonium and the smaller one as the antheridium. The smaller does not increase at all in size though if it happens to be in contact with the host it may penetrate the wall and develop rhizoids. The smaller cell discharges its entire contents into the larger. The contents of the

larger then becomes differentiated into a large globule of oil surrounded by the protoplasm. This now secretes around itself a thick wall and goes into a resting state. I have not observed the germination of this resting spore.

It would be exceedingly interesting to work out the nuclear behavior during sporangial development and during the formation of the resting bodies.

Rhizophidium pollinis (A. Br.) Zopf.

Sporangia sessile, one to many on the host cell, spherical, with a smooth colorless membrane, quite variable in thickness, from 10–30μ thick, with one or several branched rhizoids. Spores emerging slowly through one pore; about 3–4μ thick, with one cilium which is directed backwards as the spore emerges from the sporangium and as it swims through the water; spores with a single glistening globule. Resting spores also formed which are not accompanied by a smaller antheridial (?) cell; spherical, the wall smooth or sometimes punctate, 10–15μ thick, when mature containing a single conspicuous fat (?) globule embedded in the cytoplasm.

Very common around Chapel Hill, N. C., in the spring on pine pollen which has fallen into ponds and ditches and perhaps occurring at other times on other pollen.

This species has been observed a number of times in Germany, being very common on pine pollen but also occurring on the pollen of *Phlox Tropaeolum*, *Helianthus*, *Populus*, and *Amaryllis*. This is the first time the species has been reported in America (see below). The sporangia have been described as being almost always exactly spherical (Zopf, 1887). Minden (1911) describes them as being mostly exactly spherical, rarely with a short stalk or slightly ovoid. I have observed only spherical sporangia without a stalk.

Melhus (1914) has described a species of *Rhizophidium* which he found parasitizing the oospores of *Cystopus*. The sporangia of the form, as described by Melhus, are either ovoid with a stalk, or subglobose with a stalk , or pyriform. These sporangia are so distinctly different in shape from those described by Zopf (1887) that it seems hardly possible that the fungus described by Melhus (1914) is the same as *R. pollinis* as understood by Zopf (1887), Minden, and others.

Melhus (1914) was able to infect the pollen grains of hyacinth and the calla-lily with his fungus, a fact of much interest in itself, but, in view of the rather striking differences in the shape of the sporangia in the two

plants, this does not seem to be sufficient proof that this plant is identical with *R. pollinis* (A. Br.) Zopf. Another important difference between the plant studied by Melhus and *R. pollinis* as understood by Zopf is that in the former plant the resting spores are borne within the old sporangium (Melhus, 1914). Melhus also reports that he kept his parasite in culture for over a year simply by infecting fresh oospores of *Cystopus bliti* as the fungus died out in the old cultures.

The resting spores in material collected in 1925 had a finely punctate wall; the wall appeared smooth, however, in material collected at two other times. It is quite possible that two species are involved in my material.

Rhizophidium acuforme (Zopf) Fischer

Sporangia sessile, occurring singly on the host cell, spherical or slightly subspherical, 6.2–9μ thick, furnished with a distinct beak which may be as long as half the diameter of the sporangium, rhizoids delicate, branched. Spores formed within the sporangium and emerging slowly after the rupture of the end of the papilla; sporangia with 10–20 spores. Spores very minute, 1.8–2.4μ thick, with one cilium directed backwards, and with one conspicuous oil globule. No resting cells seen.

Collected only once on *Palmodicton* sp., March 25, 1928, in spring by creek on Glen Burnie Farm, Chapel Hill, N. C. The algal cells varied from 9–14μ thick and were embedded in a branched gelatinous matrix.

This species is close to *R. acuforme* (Zopf) Fischer, but that grows on the swarm cells of a *Chlamydomonas*-like alga, is considerably larger, and also has the resting spore stage. *Rhizophidium minutum* Atkinson (1909), also close to this species, may be distinguished by its habitat on *Spirogyra*, its smaller size and the presence of two to four spores in the sporangia. Atkinson did not observe the resting spores of this form. The present species seems to be intermediate between *R. acuforme* (Zopf) Fischer and *R. minutum* Atkinson, being perhaps closer to the former than the latter. I am therefore considering this a form of *R. acuforme* (Zopf) Fischer. This is the first time the species has been found since it was first described by Zopf (1884).

Rhizophidium mamillatum (A. Braun) Fischer

Sporangia sessile, occurring singly on the female sex cells of *Oedogonium* and *Draparnaldia* sp., spherical when young, becoming subspherical

by the formation of an apical or slightly lateral mammiform outgrowth; 10–22 x 10–28μ; rhizoids delicate. Spores 2–4μ thick, with one cilium, directed backwards while the spore is swimming. Resting bodies not observed.

Collected twice, February and March, 1931, from marsh by Episcopal Church, Chapel Hill, N. C.

This species is very common in Europe, having been reported on various fresh water algae as *Coleochaete pulvinata*, *Conferva bombycina*, *Draparnaldia glomerata*, *Ulothrix zonata*, and *Stigeoclonium*. This is the first record for this parasite in America.

Minden (1911) states that the spores are surrounded by a slimy material upon emerging. Unfortunately I am unable to say if the spores in this plant are also embedded in a slimy material upon emerging, since my observations on spore discharge in this species are rather scanty. I saw the spores only after they had emerged and most of them had swum away.

Rhizophidium minimum (Schroeter) Fischer

Sporangia sessile, spherical or subspherical, 5.5–10μ thick, with a tuft of thick short rhizoids. Early stages in spore development as in *R. globosum*, later stages not seen. Sporangia emptying through a single apical pore. Resting cells spherical with a tuft of rhizoids; with numerous oil globules; surrounded by a gelatinous sheath.

On *Bumilleria* sp. in the same material with *Phlyctidium Bumilleriae* but appearing after that species had mostly disappeared. This species is placed under the doubtful or insufficiently known species of *Rhizophidium* by Minden and since my material was unfortunately rather scanty, I was unable to observe spore discharge, or to add much to the knowledge of this species.

PHLYCTOCHYTRIUM

The genus *Phlyctochytrium* was established by Schroeter (1892) to include nine species which had been placed in *Rhizophidium* and *Rhizidium*, but which possessed a subsporangial vesicle from which the rhizoids arose. The genus is divided into two sections according to whether the mouth of the sporangium is bordered by several prong-like outgrowths or is smooth as in species of *Rhizophidium* as *R. globosum*. Various species are parasitic on algae and flagellates. In American two species, *P. planicorne* Atk. and *P. equale* Atk., have been found by Atkinson (1909)

on *Spirogyra*. It seems that this is the only record, up to the present time, of the genus in this country.

In this paper we are describing two species, neither of which seems to have been reported before. The description of the first is based largely on notes and drawings made by Mr. E. H. Hall, and I am naming the fungus in his honor.

Phlyctochytrium Hallii n. sp.

Sporangia sessile, one to many on the host cell, often growing on the end of the cell; spherical, with a smooth rather thick wall; variable in size, when mature 10–40μ thick, usually 20–25μ thick. Sporangia with a bulbous base which may be as large as 5 x 10μ; bulbous base sometimes apparently absent. From the base a very conspicuous rhizoidal system arises. Spores formed as in *Rhizophidium*. Spores emerging through a large conspicuous pore, the spore mass swelling and partly extending out to form the pore, after which the spores slowly free themselves from the mass. The process of spore discharge strikingly resembles that of *R. sphaerocarpum* as figured by Zopf (1884). Spores 2.1–4.2μ thick, with a glistening droplet and one posteriorly directed cilium. Spores darting here and there with great rapidity. Resting cells thick-walled, bluntly spiny, with vesicle from which rhizoids arise, no small accompanying cell seen.

This species has been collected twice at Chapel Hill, N. C., appearing both times in the late summer and early fall. On *Spirogyra* sp. July 29, 1928, E. H. Hall, coll.; Sept. 26, 1931, John Raper, coll. We have looked for it in the spring, but have been unable to find it.

The species is characterized by its occurrence on *Spirogyra*, the spherical sporangia, the very distinct rhizoids arising from the vesicle, the manner of spore discharge, and the spiny-walled resting spores.

Several species of the genus *Phlyctochytrium* occur on *Spirogyra* sp.: *P. Schenkii* (Dangeard) Schroeter, *P.* (*Rhizidiomyces*) *spirogyrae* (de Wilderman) Minden, and *P. Westii* (Massee) Lemmermann. The first of these species has much too large a vesicle and usually has ovoid sporangia. *Phlyctochytrium Hallii* differs from the other two species in having a much smaller subsporangial vesicle, and in having spiny resting spores.

In the development of the fungus there are several noteworthy points. In a number of cases we have noticed that the inner part of the cell wall of the host is considerably pushed in by the infecting rhizoid. This

appears to be due to mechanical pressure. The general effect of the parasite on the host is much the same as described for *R. globosum* (A. Br.) Schroeter. As the parasite develops the chromatophores lose their spiral form, collapsing toward the parasite. The pyrenoids are broken up and the starch disappears, and simultaneously the chloroplast changes from a brilliant green to a bluish green and finally to a brown color.

Spore discharge regularly occurs in this species in the late afternoon or early evening. In spore discharge the tip of the sporangium begins to bulge from pressure exerted by the spore mass. The inner wall stretches until about a fourth of the mass of spores protrudes from the sporangium. Then slowly the outermost spores begin to free themselves from the mass. After freeing themselves they remain quiet for a moment and then dart away with great rapidity.

The resting spores with their bluntly spiny wall are very distinctive. It is very interesting to discover them in this species, for this is the first species of the entire genus in which resting spores have been reported.

Phlyctochytrium biporosum n. sp.

Sporangia sessile, spherical at first, becoming somewhat angular when mature, 8–12.6μ thick. Sporangia with a small somewhat bulbous intramatrical base from which arises a single, thick, rhizoid which apparently branches out into smaller divisions. Spores formed as in *Rhizophidium*. Spores emerging one by one through two pores; about 2.6μ thick, spherical or slightly elongated, with one cilium directed backwards as the spore swims. Sporangial membrane disappearing soon after spore discharge. Resting spores not seen.

Collected once at Chapel Hill, N. C., Feb. 14, 1932, on *Vaucheria* sp., growing very rarely on the healthy portions of the threads but usually on the disorganized parts. Also on *Bumilleria* sp. and *Oedogonium* sp. in the same lot of material.

Because of the minute size of the parasite the bulbous base and the rhizoidal system were extremely difficult to make out. I could not be sure as to whether or not the rhizoid branched.

I have not followed through the complete development of a sporangium, but I have seen sporangia in all stages of development. The developmental stages appear to be about as in *R. globosum*. When the spores are nearly mature, one can notice a faint rocking and jerking motion, though it is difficult to make out the individual limitations of sin-

gle spores. After a while this motion ceases completely. Clear, narrow spaces appear between the spores and the spores next to the wall become somewhat flattened out against the membrane as though pressure were being exerted against them (fig. 60). The sporangium, at the same time, swells until finally the membrane gives way in two places (in all cases observed), and the spores come out. The first few spores are pushed out by internal pressure. As the pressure diminishes, the spores become active within the sporangium, some trying to swim, others crawling about over the wall in an amoeboid fashion. When a spore comes close to either pore, it creeps through the opening. The first spores which emerge have the cilia coiled around their bodies and it takes a few seconds, once the spore is outside, for the cilium to uncoil itself and get ready to propel the spore through the water. The spores which emerge later by creeping through the pores swim away almost immediately upon reaching the exterior.

The sporangia usually discharge their spores in the late afternoon (between 5 and 7 p.m.), however, I have seen spores emerging in the morning. I have observed about a half dozen sporangia in the act of discharging their spores and in all cases the spores were coming out through two openings. Even where there is a distinct apical papilla two openings will be formed in the sporangial membrane.

PHLYCTIDIUM

The genus *Phlyctidium*, containing only three species, one of which, *P. brevipes* (Atkinson) V. Minden, has been described from America, is separated from *Rhizopidium* on the basis of the absence of rhizoids in the former genus, their place being taken by a minute bulbous or discoid haustorium which merely penetrates the cell wall of the host.

In the same lot of material which yielded *Phlyctochytrium biporosum* on *Vaucheria* there was a great deal of the filamentous yellow-green alga, *Bumilleria*. In fact the dish contained mostly *Bumilleria* with a few threads of *Vaucheria* sp., a few of *Oedogonium*, and many diatoms and desmids. On the *Bumilleria* I found three different parasites, two species of *Phlyctidium*, and one of *Rhizophidium*. I was unable to get complete stages in the development of these species, but the species of *Phlyctidium* were so remarkable in that one species was parasitic on the other that I am presenting my observations now even though incomplete. The two species of *Phlyctidium* appeared first, the epidemic lasting for only about two days. After this time I could find nothing but empty

sporangia and resting spores of the one and a few empty sporangia and the parasitized bodies of the other. On the following days the species of *Rhizophidium* appeared (For description see under *Rhizophidium*). In the same lot of material two species of *Lagenidium* (*L. ecenans* Zopf and *L. oedogonii* Scherffel on *Oedogonium*) and one species of *Ancylistes* (*A. closterii*) have appeared. This seems rather remarkable since the entire lot of material only half filled a Petri dish.

Phlyctidium Bumilleriae n. sp.

Sporangia sessile, globose, 5.4–7.6μ thick, with a small bulbous or discoid base which extends into the host cell. Spores emerging through an apical pore. Spores not seen. Resting spores not seen.

The present species attacks the living healthy cells of *Bumilleria* finally destroying almost the entire cell contents. This species is very close to *P. Chlorogonii* Serbinow described from Russia on *Chlorogonium euchlorum*, but the latter species grows on dead or dying cells while the present species is parasitic.

The following species was found growing on the sporangia of the above species, and because of this extraordinary peculiarity I am calling the species *P. anomalum*.

Phlyctidium anomalum n. sp.

Sporangia sessile, ovoid or ellipsoid, 4.2–5.5 x 7.3–11.7μ, anchored to the host by a very small, bulbous or discoid base. Spore development as in *Rhizophidium globosum*. Spores in sporangium about 1.8μ thick, with a single glistening droplet. Swimming spores not seen. Sporangial discharge through an apical pore. Sporangium collapsing more or less after spore discharge. Resting cells formed from a cell of about the same size and shape as a mature sporangium. The protoplasm collects in the distal half of this cell leaving the proximal half empty and around the protoplasm a rather thick wall is formed. Resting cell with 1–3 oil globules. Rarely the mature resting cell may occupy the entire "parent" cell being elliptical in shape.

This unique species has appeared only once and except for the resting bodies lasted only two days in my material. All species of chytrids which I have studied liberate their spores generally in the afternoon or early evening. I have kept sporangia of the present species under observation until 10:15 p.m., one of these containing spores apparently mature, but none was seen to empty. On the following morning the

sporangium which contained mature spores was empty. The spores seem to come out during the night.

This species destroys the contents of the host cell so that none of the latter, if infected, ever reach maturity. I have seen a few of the resting cells of *P. anomalum* apparently attached to the algal cell, but in such cases there was a cell of *P. Bumilleriae* at its base so that I could not be certain that *P. anomalum* was not also attached to its usual host as well as to the algal cell.

UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

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EXPLANATION OF PLATES

All the plates were inked by Miss Alma Holland

PLATE 14

RHIZOPHIDIUM GLOBOSUM

Fig. 11 ×135; 12 ×325; 17, and 18 ×1080, 19 ×635, the rest ×675.

Figs. 1, 2. Spores germinating on zygote of *Spirogyra*.

Figs. 3, 4. Spores germinating not in contact with host.

Fig. 5. Showing a spore the germ tube of which has penetrated the *Spirogyra* cell, though the spore is a considerable distance from host.

Fig. 6. Late stages in spore germination.

Figs. 7, 8. Stages in the formation of the resting spore. Note that small cell is empty.

Fig. 9. A group of spores penetrating host. Note cytoplasmic currents in host cytoplasm.

Fig. 10. A remarkable case where host has apparently caused abnormal development of parasite rhizoid.

Fig. 11. Typical effect of parasite on host chloroplast. Note how it is drawn to the wall beneath parasites.

Fig. 12. Early stages in development of sporangia.

Fig. 13. Showing an unusually well developed rhizoidal system the different branches of which are attached to the sporangium at several points. Note disintegrating pyrenoids and starch grains undergoing hydrolysis.

Fig. 14. Stage in development of sporangium following fig. 13. Large globules of oil (?) have disappeared, being redistributed (?) in the form of smaller globules.

Fig. 15. Showing spores blocked out, each with a conspicuous globule. Note enlarged starch grains.

Figs. 16, 17. Spore discharge.

Fig. 18. Spore showing hollow cilium.

Fig. 19. Sporangium with well developed rhizoids; protoplast of host completely disorganized and pyrenoids and starch grains having disappeared.

PLATE 15

Figures 20 and 23 drawn by Mabel Couch Dickert; Fig. 25 drawn by Dr. J. T. Penny

RHIZOPHIDIUM POLLINIS

Figs. 20, 21. Sporangia on pollen grains of pine. Fig. 1 ×670; Fig. 2 ×834.

Fig. 22. Spores. × 834.

Figs. 23, 24. Resting spores of *R. pollinis*. Fig. 4 ×446; Fig. 5 ×834.

Fig. 25. Resting spores found in *R. pollinis* material. ×734.

RHIZOPHIDIUM ACUFORME

Fig. 26 ×234; the rest ×834

Fig. 26. Part of colony of *Palmodictyon* sp. infected with *R. acuforme*. *p*, parasite.
Figs. 27, 28. Nearly mature sporangia. In fig. 27 the upper part of algal cell was brownish, the next region green and the lower part hyaline. In fig. 28 algal cell collapsed.
Figs. 29–34. Stages in formation and discharge of spores.
Fig. 35. Larger sized spores.

RHIZOPHIDIUM MAMILLATUM

Figures × about 734

Figs. 36–38. Sporangia of different sizes.
Fig. 39. Nearly empty sporangium and spores.

PLATE 16

PHLYCTOCHYTRIUM HALLII N. SP.

All figures except 48 and 49 were drawn by Mr. E. H. Hall. All ×827
Fig. 40. Early stage in development of parasite, vesicle already apparent. Chromatophore healthy.
Fig. 41. Vesicle and rhizoids well developed, chromatophore and pyrenoids becoming disorganized.
Fig. 42. Sporagium a short while before process of spore formation starts.
Fig. 43. Mature sporangium with spores. Pyrenoids completely disappeared.
Figs. 44–46. Early stages in the discharge of the spores.
Figs. 47–49. Sporangia.
Figs. 50, 51. Resting spores.

PLATE 17

All figures ×834

PHLYCTOCHYTRIUM BIPOROSUM N. SP.

Figs. 52–59. Development of sporangia.
Fig. 60. Same sporangium as shown in fig. 59, showing swelling of intersporal substance just before discharge of spores.
Fig. 61. Spores emerging from sporangium as in fig. 60. Note cilia are wrapped about spores when they first emerge. This is true only for the first spores which emerge.
Fig. 62. Spores creeping through pores in an amoeboid fashion, the cilia directed backwards.
Fig. 63. Spores emerging. The two spores at the opening at right remained at the pore for several minutes revolving about each other.
Fig. 64. Sporangia on *Oedogonium*.
Fig. 65. Sporangium on *Bumilleria* sp.

PHLYCTIDIUM BUMILLERIAE N. SP. AND P. ANOMALUM N. SP.

Figs. 66–68. Early stages in development of sporangium and an empty sporangium of *P. Bumilleriae.*

Figs. 69–73. Various stages in the development of *P. anomalum* parasitic on *P. Bumilleriae.* The latter is about spherical and is attached to the alga, while *P. anomalum* is elongated and is attached to *P. Bumilleriae.*

Figs. 74–75. Development of spores of *P. anomalum.* Note the cells of *P. Bumilleriae* are about empty.

Figs. 76–79. Exhausted cells of *P. Bumilleriae* and empty sporangia of *P. anomalum.*

Figs. 80–83. Resting cells of *P. anomalum.* The cells are formed by the accumulation of the protoplasm in the distal half and the formation of a thick wall around this half. In fig. 80 the resting cell of *P. anomalum* is apparently attached to the algal cell.

RHIZOPHIDIUM MINIMUM

Figs. 84–86. Sporangia showing short digitate rhizoids.

Fig. 87. Resting cell.

PLATE 14

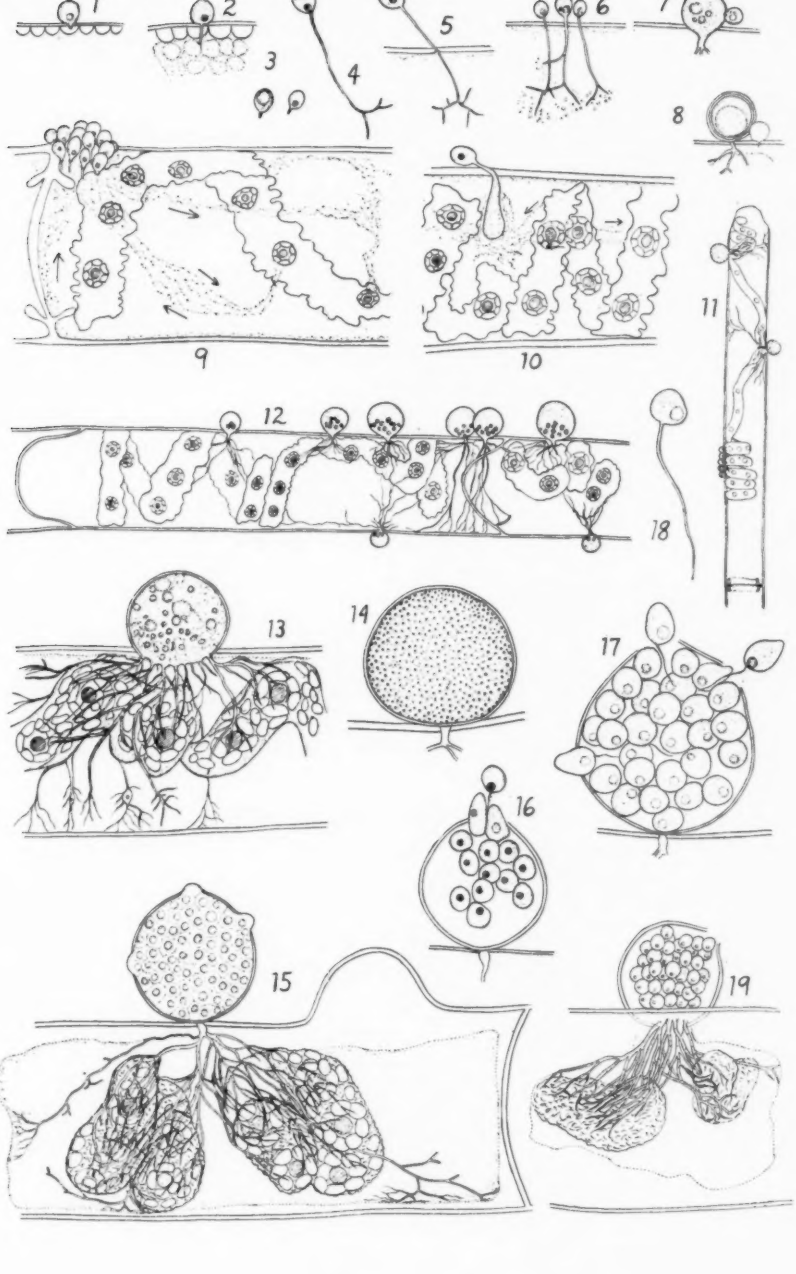


PLATE 15

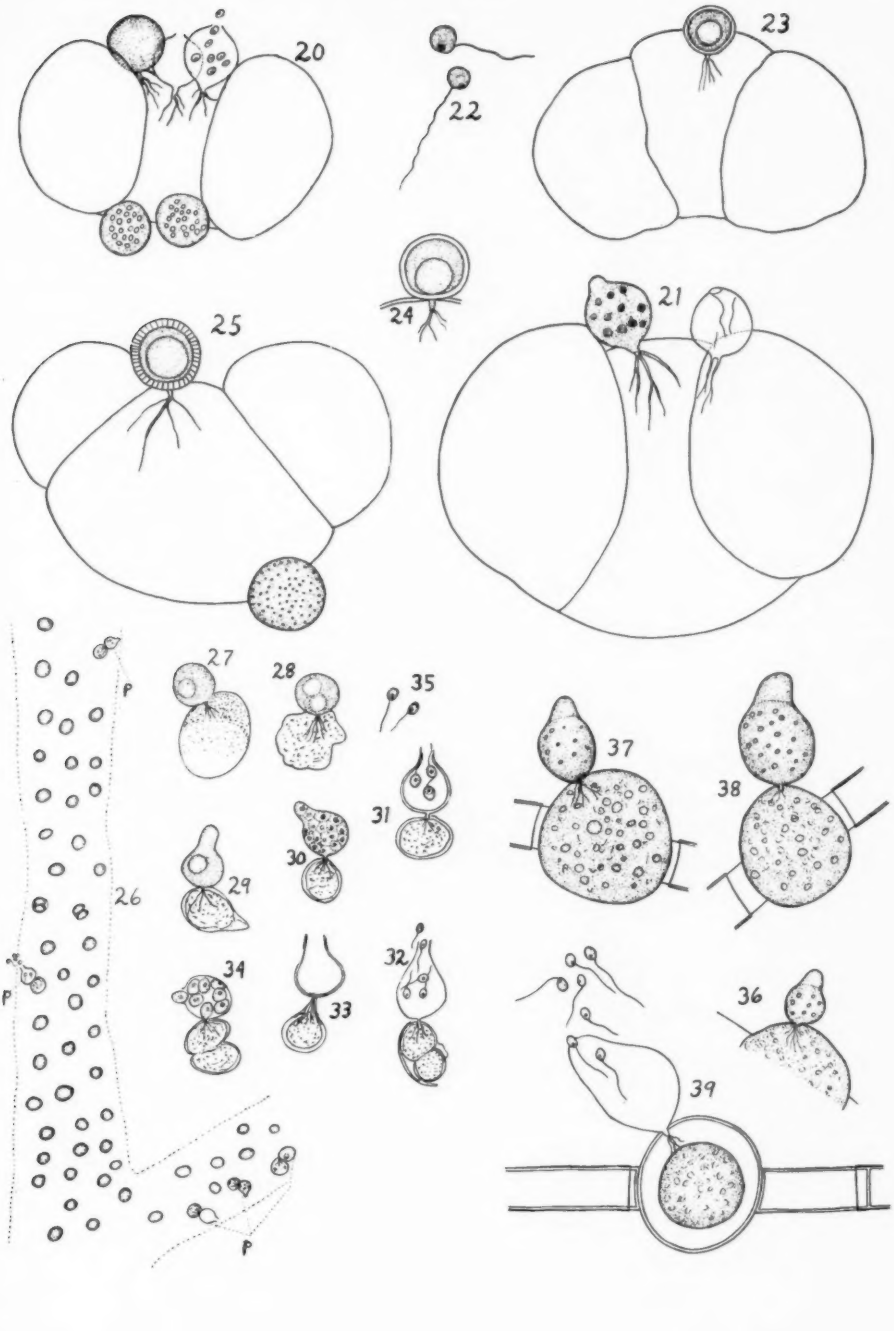


PLATE 16

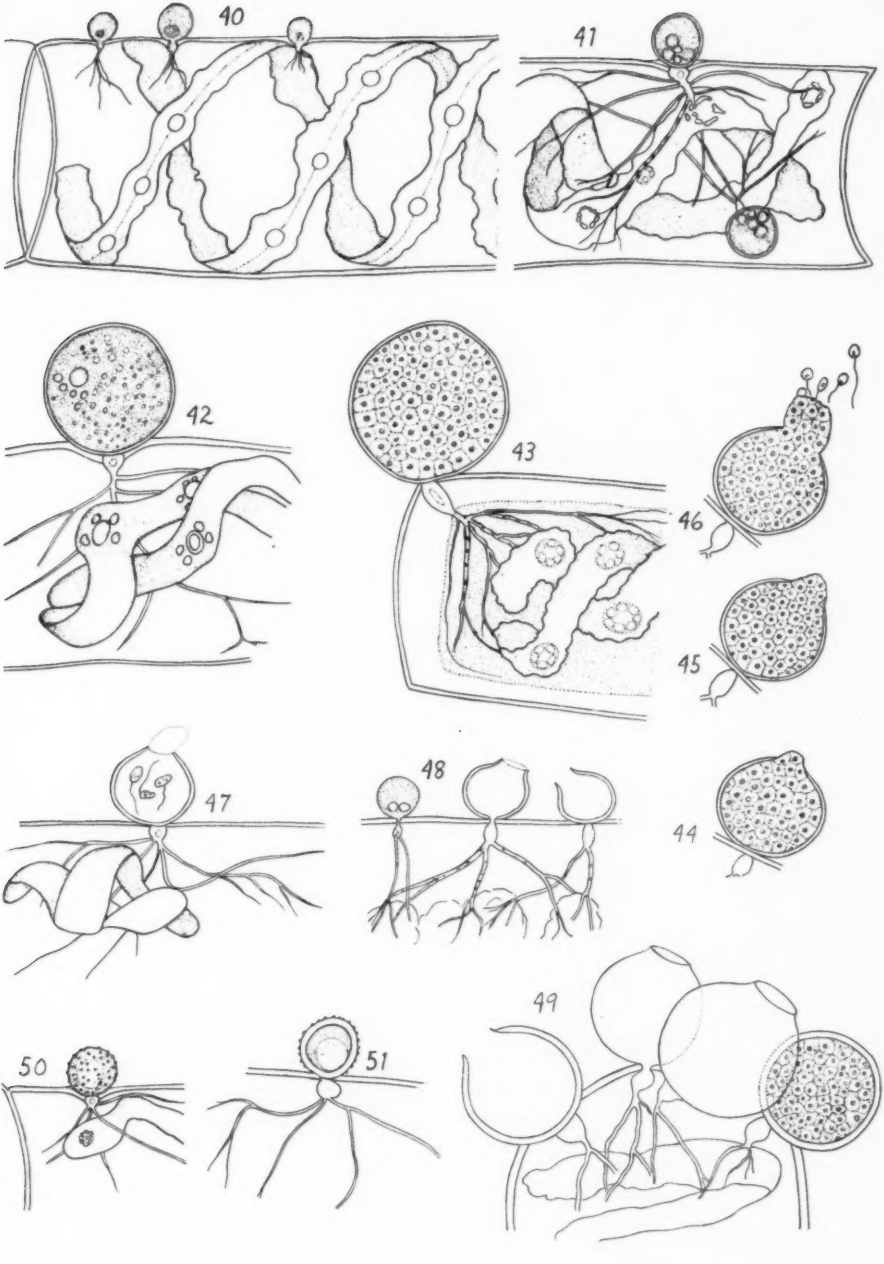
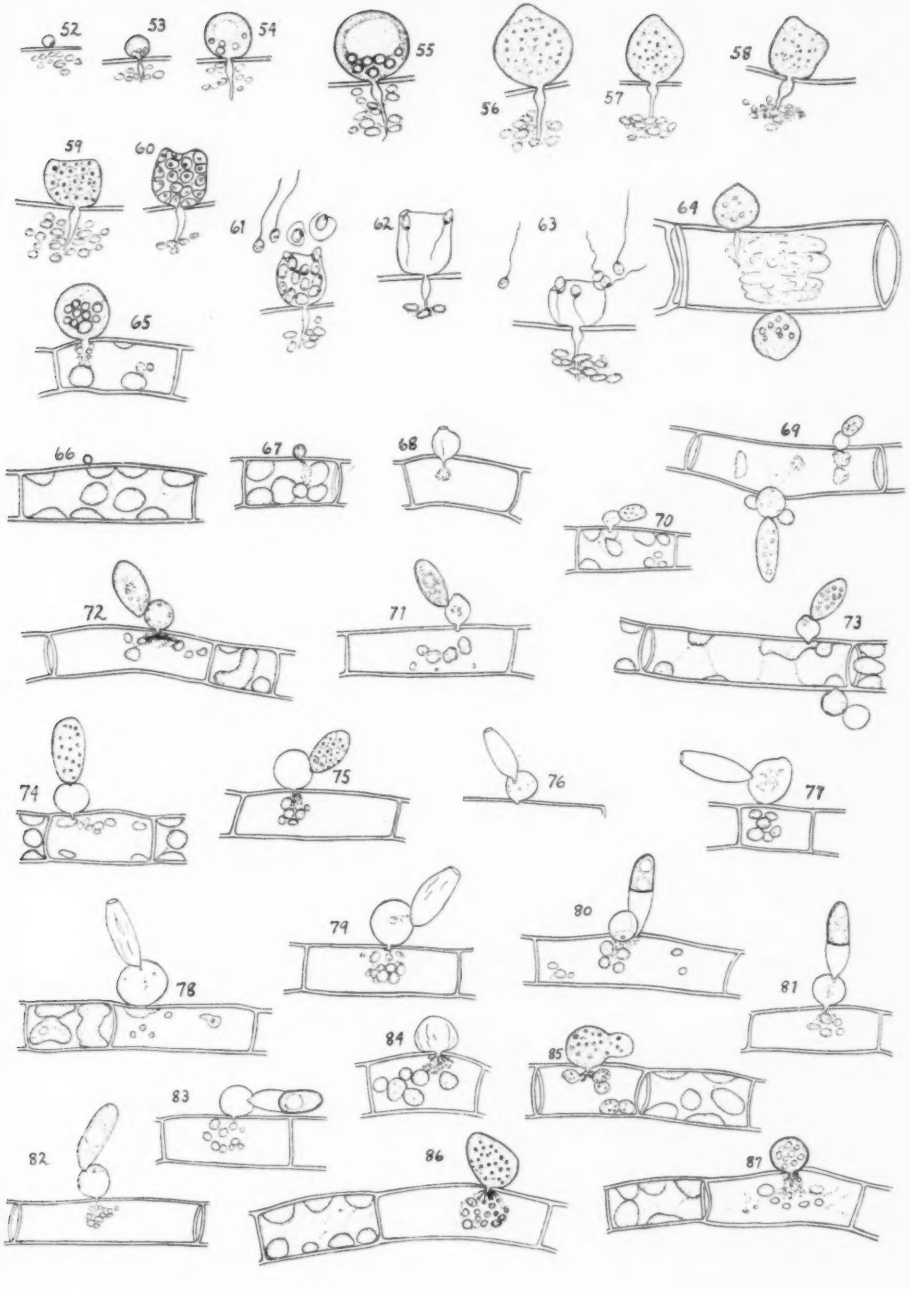


PLATE 17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A CLASSIFICATION OF THE GENUS PSEUDANOPHTHALMUS JEANNEL (FAM. CARABIDAE) WITH DESCRIPTIONS OF NEW SPECIES AND NOTES ON DISTRIBUTION

By J. Manson Valentine

National Research Fellow

Plates 18–25

The following is a review of the known representatives of a North American genus of cave-inhabiting carabids, *Pseudanophthalmus*. An attempt has been made to arrange the available material[1] in accordance with the genital structure of the male, such characters having demonstrated their extreme usefulness in separating variable species and indicating faunistic limits.

The writer wishes to express his appreciation of helpful suggestions given him by H. S. Barber and L. L. Buchanan of the U. S. Department of Agriculture. To the following owners of caves and guides he is deeply indebted for courtesies extended him while collecting the material described herein: J. J. Raulston, Wonder Cave, Tenn.; James Fuller of Chattanooga, Tenn.; O. D. Higginbotham of Frankford, W. Va.; Horton Fuson of Cumberland Gap, Tenn.

Technique: all measurements of curved surfaces represent the chords of such surfaces and were taken by optically bending the insect or its appendages at the points of articulation only. Antennal segments were measured along their posterior face, their greatest length being recorded. By the *antennal index* is meant the ratio between the total length of the antenna and the total body length, while the *segmental index* is the length of the 2nd basal segment divided by the length of the 3rd. The *setal index* refers to the length of the humeral set of 4 marginal setigerous papillae divided by the distance between the 4th papilla (most posterior of this series) and the 5th (more anterior of the medial marginal set of 2). The *genital index* is the penial length measured as the chord of the median lobe inclusive of the basal plate in ratio to the total length of the insect (the distance from the further elytral apex to the furthest anterior point of the closed mandibles).

[1] Paratypes deposited in the U. S. National Museum.

The figures are by the author and are camera lucida sketches drawn to the following scales: the detailed drawings of the entire insect and pronota are magnified × 21; to better indicate details, the pubescence and gross sculpturing has been omitted from the left elytron, while the striae have been omitted from the right. The detailed views of male genitalia viewed laterally are magnified × 95; viewed sagittally, × 40. Outline drawings of whole insects and pronota are magnified × 14, while the outlines of male genitalia are enlarged × 40.

GROUP HUBBARDI

Small (not over 4.5 mm). Elongate, flattened. Appendages of moderate length. Labral margin concave. Antenna with segment 2 about 8 tenths the length of segment 3. Humeri angular; anterior humeral border sloping; marginal setae well distributed; striae feebly impressed, apical groove short, straightened anterior to elytral margin. Male genitalia: median lobe of moderate length; basal plate well developed; viewed laterally, basal flexure not strong, median lobe slightly arched, produced distally and terminating bluntly in a small, slightly upturned process enlarged at the tip; viewed sagittally, rather slender, widening near the distal aperture beyond which the apex is fusiform and bent slightly to the right; copulatory pieces short, comprising a slender style and an upturned spout-like spatula; setae of lateral lobes long.

Inhabiting caves along the tributaries of the Potomac River, Va., and W. Va.

I. Species in which the marginal setae are relatively well grouped. Penis relatively arciform; setae 3, the central one shorter than the laterals.

Western branches of the Potomac River, W. Va.

Pseudanophthalmus potomaca Valentine sp. nov.

Length 4.0 mm. Resembles *hubbardi*. Head distinctly reticulate, rugosely so anteriorly. Antennal index .65; segmental index .8. Pronotum more transverse than in *hubbardi*. Setal index .7. Genital index .14; apex of penis a simple blunt process (Plate 18, Figs. 1, 2).

Simmons' Cave, Cave, W. Va. (on South Branch Potomac River, 10 miles south of Franklin, W. Va.). A single male was take on the muddy bank of a stream running at the bottom of a well-like depression in the cave.

Type: male, coll. Valentine.

a) *P. potomaca senecae* Valentine subsp. nov.

Length 4.3 mm. More slender throughout than the last which it closely resembles. Antennal index .62; segmental index .8. Setal index .8. Genital index .14; penis slightly more slender and terminating in a definitely enlarged tip. (Plate 18, Figs. 3, 4).

Seneca Caves (on the North Fork Potomac River, 4 miles northeast of Riverton, W. Va.). A single male was taken in the cave lying furthest to the north of the group of three; it was found among cave pebbles on the wet, terraced floor beside a small pool of drip-water.

Type: male, coll. Valentine.

II. Species having the marginal setae widely distributed. Penis relatively straight distal to the basal flexure, the apex more produced and, except for the termial enlargement, is not directed upward; setae 4.

Branches of the Shenandoah River, Va.

Pseudanophthalmus hubbardi Barber 1928

Length 3.8–4.3 mm. Antennal index .63; segmental index .8. Setal index .9. Genital index .17. (Plate 18, Fig. 7.)

Luray Caverns, Luray, Va. (on the South Fork Shenandoah River). 2 specimens were discovered among the stones of a wet, muddy pocket in the wall of a lower-level chamber.

a) *P. hubbardi limicola* Jeannel 1931—Madden's Cave, New Market, Va. (on the North Fork Shenandoah River).

b) *P. hubbardi parvicollis* Jeannel 1931—Battlefield Crystal Cave, Strasburg, Va. (on the North Fork Shenandoah River).

GROUP GRANDIS

Size small to large (4–7 mm.). Convex species. Appendages long. Labrum relatively wide, its marginal concavity shallow. Humeri reduced, anterior humeral border oblique; striae feebly impressed, apical groove moderate in length, usually sinu-arcuate. Genital index high; median lobe elongate, slender; basal plate well developed; viewed laterally median lobe constricted near the basal flexure which is usually not abrupt; distal to this point the penis is straightened or gently arcuate; the apex beyond the distal aperture is much produced, its tip being upturned to form a conspicuous blunt hook; viewed sagittally, the median lobe is slender, slightly enlarged at the basal bulb but not flaring much near the distal aperture, apex fusiform, blunt and usually sinusoid; copulatory pieces consist in 2 rather short rounded spatulae; setae of lateral lobes long, not less than 4, the dorsal one shorter.

Inhabiting caves along the New River, Va., and its tributary the Greenbrier River, W. Va.

I. Small relatively flattened species. Labral margin concave. Antenna relatively short, the 3rd segment 1 tenth shorter than the 2nd. Humeri much rounded; marginal setae normally distributed. Genital index very high.

New River, Va.

Pseudanophthalmus gracilis Valentine 1931

Length 4–4.2 mm. Very slender, legs long. Antennal index .65; segmental index .9. Setal index .7. Genital index .21; penis much flattened below from basal flexure to apex and well produced apically; terminal hook very slender, enlarged at tip; internal groove on right side very long; setae 4 (Plate 19, Fig. 3).

Tony's Cave, Newport, Va. (on Sinking Creek, 2 miles west of Newport); taken running over rotting wood and in mud crevices along the cave stream.

II. Large, very convex species. Labral margin with tendency to produce a small central lobe. Terminal segment of labial palpi strikingly shorter than subterminal (8 tenths of latter). Antennae very long, the 3rd segment about 3 tenths longer than the 2nd. Humeri distinct; marginal setae confined in widely separated groups.

Cursorial types inhabiting the wet caves of the Greenbrier Valley, W. Va.

Pseudanophthalmus grandis Valentine 1931

Length 4.9–6.8 mm. Strongly convex, elytra widening in posterior third. Antennal index .74; segmental index .7. Setal index .4. Genital index .20; penis slightly arciform, very slender, its apex sinuate, the terminal hook very blunt; setae 4 (Plate 20, Fig. 2).

Higginbotham's 3 caves, Frankford, W. Va. (1 mile northwest of Frankford on O. D. Higginbotham's farm); Coffman's cave (1.5 miles southwest of Frankford on Coffman's farm); Arbuckle's cave, Maxwelton, W. Va. (.2 mile east of Maxwelton on Dr. Arbuckle's farm). These caves are west of the Greenbrier River.

This is a very common form occurring frequently on the muddy banks of the cave streams; where any débris in the form of rotting wood has accumulated it may be taken in large numbers.

The remarkable range in variation of form in this species may be studied from Plate 24. The 4 figures representing head and elytra correlation illustrate the extremes of the 4 categories into which a series of

75 individuals has been roughly divided. Although there is exhibited in this material a decided tendency for factors to appear inducing general elongation or general broadening of head, pronotum and elytra, it will be seen from types 2 and 3 that forms do occur in which broad elytra are accompanied by a rather narrow head and vice versa. In other words, head and elytra are capable, within limits, of independent variation. The same holds true of the pronotum which varies so remarkably within the species that a series of these parts has been figured to depict the phenomenon. However, it is apparent that the broadest pronota are associated with the extreme transverse type of head and elytra while the very elongate pronota are found in combination with the extremely attenuate contour. There is little to correlate these body differences with genital distinctions: the only noteworthy genital differentiation is a slight angulation in the median lobe of types 3 and 4 (the relatively narrow insects) as contrasted with types 1 and 2 (the relatively transverse insects). The proportions in which the 4 types appear in the series are as follows: type 1, 31%; type 2, 31%; type 3, 12%; type 4, 25%. It may be added that the 4 Frankford caves, from which this series was taken, are probably connected; there is no indication of segregation suggested by the predominance of any one set of characters in any of the caves (Plates 24, 25).

a) *P. grandis elevatus* Valentine subsp. nov.

Length 5.5–5.7 mm. Antennal ratio .76; segmental ratio .7. Hind angles of pronotum more elevated and produced than in race *grandis*. Setal ratio .5. Genital ratio .19; penis more slender, more arciform and more elevated centrally than in race *grandis;* setae 5 (Plate 20, Fig. 1).

Organ Cave, Ronceverte, W. Va. (2 miles southeast of Ronceverte, east of the Greenbrier River); common running over little mud flats along the rocky edge of the cave stream.

Type: male, coll. Valentine.

b) *P. grandis orthosulcatus* Valentine subsp. nov.

Length 5.2 mm. Apical groove straight anterior to margin. Antennal ratio .73; segmental ratio .7. Setal ratio .4.

Greenville, W. Va. (east of the Greenbrier River; cave opening about 800 ft. north of the village). A single female was found walking over the moist mud of the margin of a cave stream bed.

After examination of male genitalia, this form may very probably be separated as a distinct species.

Type: female, coll. Valentine.

Pseudanophthalmus hypertrichosis Valentine sp. nov.

Length 5–5.7 mm. Pale brownish yellow. More elongate than the average *grandis* and much more depressed. Labrum wide, with marginal median lobe distinct. Antennal index .77; segmental index .8. Pronotum with sides nearly straight throughout the basal 2 thirds, converging strongly. Pronotum sparsely pilose, the hairs long. Elytra more coarsely pubescent than *grandis* and each equipped with 1 to 3 super-numerary sutural setae; setal index .5. Genital index .20; penis much straighter than in *grandis*, sinuate, with very acute basal flexure; setae 4 (Plate 19, Figs. 1, 2).

Martha Clarke Cave, Hillsboro, W. Va. (2 miles southwest of Hillsboro). Common on little mud patches between the stones of the cave stream.

Type: male, coll. Valentine.

GROUP FUSCUS

Closely related to the last group. Small to medium (3.5–5.5 mm.). Appendages shorter. Body more flattened. Labrum less transverse, its margin more deeply excavated. Elytra rectangular or elliptical; humeri rounded, anterior humeral margin transverse or nearly so; marginal setae normally distributed; striae feebly impressed, apical groove short, crescentic or straightened anteriorly. Genital index not high; median lobe, viewed laterally, slender, arciform, less constricted near the basal flexure, slightly deepened near the distal aperture, the apex much less produced and terminating in a slightly upturned enlargement; viewed sagittally, very slender with pronounced basal bulb and widening near the distal orifice, apex lanceolate; copulatory pieces similar to *group grandis* but rather longer; setae of lateral lobes 3 or 4.

Inhabiting caves on the New River and its tributaries.

I. Small species. Labrum rather deeply excavate. Antenna short; the 3rd segment 1 tenth longer than the 2nd. Apex of penis not produced; setae 4.

Pseudanophthalmus punctatus Valentine sp. nov.

(syn. *P. pusio* var. *punctatus* Valentine 1931)[2]

Length 3.5–4 mm. Head finely but densely reticulo-punctate. Antennal index .58; segmental index .9. Setal index .6. Genital index .17; apex of penis not extended far beyond tip of copulatory pieces *in situ* (Plate 20, Fig. 5).

[2] Jour. Elisha Mitchell Sc. Soc. **46**: 250. 1931.

Tony's Cave, Newport, Va. (on Sinking Creek, 2 miles west of Newport). Common on bits of wet rotting wood and in crevices of the mud bank along the cave stream, in association with *P. punctatus*).

Type: coll. Valentine (*P. pusio punctatus*)

This form undoubtedly represents a connecting link between *P. pusio* and *P. fuscus*. Although it resembles the former in both outward appearance and in genitalia, the male genital characters exhibit a still closer approach to the *fuscus* group.

II. Medium to large species. Antennae long; the 3rd segment 3 tenths longer than the 2nd. Apex of penis well produced into a sinuous process extending well beyond the tip of the copulatory pieces *in situ;* setae 3, the central one shortest.

Pseudanophthalmus fuscus Valentine 1931

(syn. *P. subaequalis* Valentine 1931)[3]

Length 4.4–5.6 mm. Antennal index .74; segmental index .7. Pronotum with wide, strongly reflexed margins. Humeri broadly rounded. Setal index .6. Genital index .16; penis laterally constricted between basal bulb and distal enlargement (Plate 20, Fig. 4).

Higginbotham's 3 caves and Coffman's cave, Frankford, W. Va.; Arbuckle's cave, Maxwelton, W. Va. These caves are west of the Greenbrier River. A species found in association with *grandis* but in much smaller numbers.

As in the case of *grandis* this insect is subject to considerable variation especially in the contour of the pronotum. After a sufficient series had been taken, it became clear to the writer that what had been described by him previously as *subaequalis* was merely an extreme variant of *fuscus*. This was confirmed by a comparison of the genitalia of the two forms which revealed a close similarity (Plate 25).

a) *P. fuscus constrictus* Valentine subsp. nov.

Length 5.3 mm. More elongate than race *fuscus*. Antennal index .70; segmental index .7. Pronotum narrow, the margins less conspicuous. Humeri abrupt, the elytra narrow behind them. Setal index .6. Genital index .17; penis less arched and with a less pronounced distal expansion (Plate 20, Fig. 3).

[3] Jour. Elisha Mitchell Sc. Soc. **46**: 255. 1931.

Organ Cave, Ronceverte, W. Va. (2 miles southeast of Ronceverte, east of the Greenbrier River). Taken in association with *grandis elevatus* but much more infrequently.

Type: male, coll. Valentine.

GROUP PUSIO

Small, not over 4.5 mm. Related to *group fuscus*. Broad, flattened forms. Appendages of moderate length. Labral margin deeply concave. Segment 3 of antenna 1 tenth longer than segment 2. Elytra ovoid; humeri prominent; anterior humeral margin very transverse. Marginal setae normally distributed; striae feebly impressed, apical groove short, feebly arcuate anteriorly. Genital index low due to the fact that the median lobe exhibits a strong medial flexure; viewed laterally, the median lobe is very slender, the basal plate terminal, the basal bulb large and the basal flexure weak, the apex feebly produced, straight, terminating in a blunt enlargement; viewed sagittally, the median lobe relatively stouter, its distal enlargement more conspicuous than the basal bulb; the copulatory pieces consist of a rod-like body and a narrow spatula.

Inhabiting caves in the watershed of the Roanoke River, Va.

Pseudanophthalmus pusio Horn 1868

Length 4–4.5 mm. Labrum with lateral lobes widely diverging. Antennal index .61; segmental index .9. Elytra unusually broad. Setal index .7. Penis with lateral lobes of normal width, supplied with 4 setae (Plate 18, Fig. 5).

Erhart's cave, Christiansburg, Va. (on a tributary of the North Fork Roanoke River, 5 miles east of Christiansburg). A single female was found among the moist, muddy stones in an inner recess of this cave; it corresponds perfectly with the type *pusio* in the Academy of Natural Sciences in Philadelphia.

a) *P. pusio bathycola* Valentine subsp. nov.

Length 3.8–4 mm. Narrower throughout than race *pusio* and not so depressed. Labrum with lateral lobes more parallel. Antennal index .65; segmental index .9. Setal index .6. Genital index .15; penis with lateral lobes slender, supplied with but 3 setae (Plate 18, Fig. 6; Plate 20, Fig. 6).

Aunt Nellie's cave, Blacksburg, Va. (on tributary of the North Fork Roanoke River, 3 miles southeast of Blacksburg); specimens taken on

wet decaying boards in the forks at the bottom of this well-like cave, within reach of faint daylight.

GROUP HIGGINBOTHAMI

Small, not over 4.5 mm. Rather depressed. Appendages normal. Labrum transverse, the marginal excavation shallow. Antenna with 3rd segment 1 tenth longer than 2nd. Humeri rather strong, anterior humeral border nearly transverse; marginal setae normally distributed; striae feebly impressed, apical groove short, crescentic, straightening anteriorly. Genital index very low; median lobe not produced apically, viewed laterally, gently arcuate, diameter uniform, basal plate large, subterminal, basal bulb small, basal flexure vague, apex bluntly rounded; viewed sagittally, slightly enlarged near distal orifice which is terminal, apex obtusely angular; copulatory pieces small; setae of lateral lobes 4.

An aberrant group inhabiting wet caves in the valley of the Greenbrier River, W. Va.

Pseudanophthalmus higginbothami Valentine 1931

Length 3.6–4.3 mm. Pronotum with hind angles elevated and usually much produced behind. Antennal index .64; segmental index .9. Setal index .6. Genital index .13 (Plate 21, Fig. 8).

Higginbotham's 3 caves and Coffman's cave, Frankford, W. Va. Taken much more infrequently than either *grandis* or *fuscus* with which species it occurs on the mud banks of the cave streams and on the moist stony floors of higher chambers.

GROUP HIRSUTUS

Small, not over 4.5 mm. Slender, depressed. Appendages long. Setae hypertrophied. 2nd segment of antenna variable in length. Labrum with median lobe, the lateral lobes produced. Elytra elongate-oval, flattened centrally; humeri distinct with anterior borders sloping; marginal setae normally distributed; striae feebly impressed, apical groove long, bisinuate. Penis very small; median lobe, viewed laterally, arcuate, with a well developed basal plate; little enlargement either at the basal bulb or the distal aperture which is subterminal, the basal flexure wanting, the apex only slightly produced and feebly reflexed, ending bluntly; viewed sagittally, slightly constricted between the basal bulb and the distal aperture, copulatory pieces rather short; setae 3, extending beyond the apex.

Inhabiting caves in the Tennessee River watershed, Va. and Tenn.

Pseudanophthalmus hirsutus Valentine 1931

Length 3.5–4.5 mm. Antennal index .69; segmental index .8. Sides of pronotum nearly straight. Setal index .6. Genital index. 12; penis slender, well arched (Plate 21, Fig. 6).

King Solomon's Cave, Va., Cumberland Gap, Tenn. (on south face of Cumberland Mt. near the Gap; the cave stream enters Gap Creek which flows into the Powell River); many taken on wet rotting boards bridging a pool in one of the higher galleries.

a) *P. hirsutus delicatus* Valentine subsp. nov.

Length 3.7–3.9 mm. Antennal index .70; segmental index .7. Sides of pronotum sinuate. Setal index .7. Genital index .12; penis stouter and straighter than in race *hirsutus* (Plate 21, Figs. 4, 5).

Gilly's cave, Pennington Gap, Va. (1 mile south of Pennington Gap, well up on the side of a small mountain in the watershed of Cane Creek which enters the Powell River).

Pseudanophalmus digitus Valentine sp. nov.

Length 4 mm. Pale straw yellow. Elongate. Head, including labrum, densely reticulo-punctate. Antennal index .69; 2nd and 3rd antennal segments subequal, index .9. Pronotum more parallel than in the forms just considered; as in the latter, its disc supplied with several long hairs; internal basal angles very prominent. Elytra elongate-rectangular, its sides subparallel; wider at the humeri than throughout the apical third; humeri angular; very sparsely but rather coarsely pubescent; setal index .7 (Plate 21, Fig. 7).

Tennessee River, Raccoon Mt., Chattanooga, Tenn. (on the south side of the Tennessee River about 5 miles west of Chattanooga). A single female was taken among wet rotting chips of wood and bark beside a small cave stream, 3 quarters of a mile from the entrance.

Type: female, coll. Valentine.

Although the species closely resembles those from the Powell River, it must be tentatively included in this group prior to a dissection of male genitalia.

GROUP ENGELHARDTI

Size small to medium (not more than 5 mm.). Related to *group hirsutus* but broader and more convex, depressed but less flattened discally. Appendages of average length. Labrum with a central lobe, the marginals not produced. 2nd segment of antenna 2–3 tenths shorter

than the 3rd. Humeri prominent, rounded or angular, anterior humeral border transverse or nearly so; marginal setae well distributed; striae more impressed than in the preceding groups, irregularly punctate, apical groove straight or bisinuate anteriorly. Genital index consistently low; viewed laterally, the median lobe is flattened ventrally, strongly arched above, the basal bulb being large and downwardly produced but without constriction demarking it from the remainder of the tube, the basal plate present but reduced, subterminal, the basal flexure strong (about 130°), marking the most elevated portion of the tube, apex produced into a spout-like, decumbent, truncate process; viewed, sagittally, straight, slender, enlarged at the basal bulb and at the distal aperture, constricted beyond the latter, the apex expanded, angular, acute, copulatory pieces forming a long fusiform body; the lateral fold long.

Inhabiting caves along the Tennessee River and its tributaries.

I. Species in which the penis terminates in a broadly truncate spout-like process which, viewed in profile, is slightly dilated at the tip. 2nd segment of antenna 8 tenths the length of 3rd.

The Powell and Tennessee Rivers.

Pseudanophalmus engelhardti Barber 1928

Length 4–4.2 mm. Antennal index .67. Elytra elongate-oval, the humeral margins rather sloping. Setal index .9. Genital index .13; lateral lobes, seen in profile, relatively wide; setae 4 (Plate 22, Fig. 3).

English cave, Tenn. (on the south side of the Powell River, 6 miles southeast of Cumberland Gap, Va.). Several taken among the wet rotting boards which littered the floor of this cave.

Pseudanophthalmus rotundatus Valentine sp. nov.

Length 4.0 mm. Short, very broad. Pale yellowish brown. Head round, densely and finely scabrose. Labrum with median lobe much reduced. Antennal index .65. Pronotum more rounded than in *engelhardti*, 9 tenths as long as wide; margin wide; the hind angles rectangular; an apico-discal, triangular area coarsely and densely scabrose. Elytra broadly rectangular; the sides subparallel, strongly margined, distinctly serrate and ciliated; humeri unusually full, the anterior humeral borders transverse, rounded; sparsely pubescent; setal index .8; striae feebly punctate, apical groove as in *engelhardti*. Genital index .13; penis resembles closely that of *engelhardti* but is more angular, less slender distally, with long copulatory pieces and more slender lateral lobes (Plate 22, Figs. 1, 2).

English Cave, Tenn. A pair was collected in association with *engelhardti*.

Type: male, coll. Valentine.

It is remarkable that two such closely related forms should be found in the same cave and living together under the same conditions.

Pseudanophthalmus fulleri Valentine sp. nov.

Length 4.6 mm. Elongate. Dark reddish brown, legs yellowish. Head very round, finely reticulose, becoming scabrose between the optic areas; frontal grooves shallow, short. Labrum with reduced median lobe. Antennal index .65. Pronotum 8 tenths as long as wide; sides gently arcuate; hind angles rectangular; finely alutaceous, apical triangle scabrose. Elytra elongate-oval; humeri angular, anterior borders nearly transverse; finely, sparsely pubescent; striae well indicated, punctate; setal index .8 (Plate 22, Fig. 9).

Tennessee Cave, Chattanooga, Tenn. A single female was taken among moist cave pebbles on a terraced floor in a stalactitic chamber.

Type: female, coll. Valentine.

This insect and *digitus* occur in the same cave but in different situations. The writer takes pleasure in naming the former after James Fuller, whose aid and ability as a guide enabled him to make both these interesting captures.

Pseudanophthalmus lodingi Valentine 1931

Length 4.2–4.4 mm. Less elongate than *engelhardti*. Antennal index .7. Genital index .14; penis as in *engelhardti* but with apex, in profile, more parallel, copulatory pieces longer, lateral lobes more slender, armed with 3 short setae (Plate 22, Fig. 4).

Shelta Cave, Huntsville, Ala. (1 mile west of Huntsville and 8 miles north of the Tennessee River). Among wet rotting planks within 500 ft. of the entrance.

II. Species in which the penial apex, viewed in profile, is unexpanded at its extreme tip. 2nd segment of antenna 7 tenths of 3rd.

The Elk River, Tenn. (a tributary of the Tennessee).

Pseudanophthalmus humeralis Valentine 1931

Length 3.9–4.5 mm. Similar to *lodingi*. Antennal index .71. Setal index .9. Genital index .14; apex of lateral lobe, viewed in profile, extended into a process of uniform diameter having a rounded end; setae 4. (Plate 22, Figs. 6, 7.)

Crystal Cave, Monteagle, Tenn. (4 miles north of Monteagle, close to Wonder Cave). Taken on rotting wood along the cave stream.

a) *P. humeralis brevis* Valentine subsp. nov.

Length 3.9–4.0 mm. Similar to race *humeralis* but smaller. Pronotum slightly narrower. Antennal index .72. Setal index .9. Genital index .14; penial apex more slender, tapering slightly; setae 3 (Plate 22, Figs. 5, 8).

Wonder Cave, Monteagle, Tenn. (the larger of the two Monteagle caves, separated by about 1 fourth of a mile). Taken on moist rotting accumulations of wood in the upper stalactitic rooms as well as along the cave river.

Type: male, coll. Valentine.

As the two forms of *humeralis* are quite distinct, it is probable that passage between Wonder and Crystal Caves is difficult or impossible at present.

GROUP ALABAMAE

Size medium. Related closely to group *engelhardti*, having nearly all the characteristics of the latter. More convex. Apical groove shorter, straighter. Genital ratio low; the median lobe, viewed laterally, elevated at the distal aperture, not at the basal flexure, apex decumbent, tapering downward to a rounded point; viewed sagittally, strongly constricted between the basal bulb and the greatly expanded lateral lips which suddenly are constricted behind a narrow, rounded apex, the copulatory pieces forming a tongue-like, distally expanded body; the lateral lobes strong, armed with 5 setae.

Drainage of the Coosa River, Ala.

Pseudanophthalmus alabamae Valentine sp. nov.

Length 4.6 mm. Elongate. Light reddish brown, legs straw-yellow. Head elongate; alutaceous. Labrum with distinct median lobe. Antennal index .70; segmental index .8. Pronotum 9 tenths as long as wide; the sides gently arcuate; the hind angles rectangular. Elytra elliptical; humeri angular, anterior borders nearly transverse; striae well indicated, feebly punctate, the intervals convex; discal setae long, setal index .7; pubescence rather fine, sparse. Genital index .13 (Plate 21, Figs. 1, 2).

Manitou Cave, Ft. Payne, Ala. (1.5 miles southwest of Ft. Payne, at the foot of Lookout Mt., in Coosa River drainage). Several were taken among the rotting timbers along a wet muddy passage.

Type: male, coll. Valentine.

Since Lookout Mt., which extends northeast 50 miles to the Tennessee River at Chattanooga, is thought to be cavernous throughout its entire extent, it is not surprising to find an anophthalmid of such close affinities to *group engelhardti* a long distance from the river and in a new drainage system.

GROUP ROBUSTUS

Size medium (not over 5 mm.). Broad, depressed. Appendages of average length. Labrum with median lobe. Segment 2 and 3 subequal. Humeri very broad, angular, keeled, anterior border transverse. Elytral striae well indicated, strongly punctate, marginal setae well distributed; apical groove very short, crescentic. Genital index high; viewed laterally, median lobe elongate, gently arcuate, with well developed basal plate, ill defined basal bulb and basal flexure, apex sinuate, produced into an elongate, decumbent, slender lobe; viewed sagittally, basal bulb enlarged, suddenly constricted distal to the aperture and thence produced into a slender, finger-like process; lateral lobes very slender, their setae 4.

Watershed of the Cumberland River, Tenn.

Pseudanophthalmus robustus Valentine 1931

Length 4–5 mm. Antennal index 4.5; segmental index .9. Setal index .9. Genital index .19 (Plate 23, Fig. 1).

Johnson's cave, Monterey, Tenn. (6.5 miles southwest of Monterey, on the Calfkiller River). Common on wood rotting under the drip-water in the large entrance chamber.

GROUP MENETRIESI

Size medium to large (not over 6 mm.). Similar in outward form but more convex than *robustus*. Antenna of average length, segment 2 considerably shorter than segment 3. Marginal setae well grouped; striae deep, punctate, apical groove short, not clearly distinguishable in character from the striae. Genital index very low; penis robust; viewed laterally, median lobe with large basal bulb much produced downward, basal flexure strong, distal aperture subterminal, the apex only slightly produced and in the axis of the basal line which is quite straight; viewed sagittally, the lateral lobe is subparallel, the apex suddenly constricted and slightly produced; setae short.

Caves on the Green River, Ky., and its tributaries.

Pseudanophthalmus menetriesi Mots. 1862

Length 5–6 mm. Antennal index .61; segmental index .7. Setal index .12. Mammoth Cave center, Glasgow Junction, Ky. (Plate 23, Fig. 3).

Pseudanophthalmus striatus Mots. 1862

Length 5–5.5 mm. Antennal index .68; segmental index .7. Setal index .6. Mammoth Cave center, Glasgow Junction, Ky.

Pseudanophthalmus pubescens Horn 1868

Length 5.5–6. Antennal index .70; segmental index .7. Setal index .7. Mammoth Cave center, Glasgow Junction, Ky.

Pseudanophthalmus audax Horn 1883

Length 4–4.5 mm. Mammoth Cave center, Glasgow Junction, Ky.

GROUP EREMITA

Size medium to large (not over 6 mm.). Convex elongate forms. Labrum with well formed central lobe, lateral lobes produced. Antenna of average length, the 2nd segment considerably shorter than the 3rd. Striae feebly impressed, weakly punctate, apical groove as in *group menetriesi*; setae well grouped. Genital index rather low; viewed laterally, median lobe much arched causing the basal flexure to become extremely vague; basal bulb large, produced behind, elevated near the distal aperture which is subterminal, apex not produced; viewed sagittally, robust, greatly enlarged apically, apex not produced; copulatory pieces consist in two plate-like bodies, a distinct departure from the usual equipment; setae 4, rather short.

Caves in a relatively restricted area on both sides of the Ohio River.

Pseudanophthalmus eremita Horn 1871

Length 4.5–6 mm. Wyandotte Cave, Wyandotte, Ind.

a) *P. eremita stricticollis* Jeannel 1931—Marengo Cave, Wyandotte, Ind.

b) *P. eremita morrisoni* Jeannel 1931—Donnelson's cave, Mitchell, Ind.

c) *P. eremita barberi* Jeannel 1928—Rockhaven Cave, Brandenburg, Ky. Length 5.3 mm. Antennal index .65; segmental index .7. Setal index .5. Genital index .15 (Plate 23, Fig. 2).

GROUP HORNI

Small (not over 4.5 mm.). Flattened species. Labrum with a faint median lobe. Antenna of average length, the 2nd segment equal to the 3rd. Marginal setae not closely grouped; only the discal striae evident, these deep, the short apical groove flowing without interruption into the 3rd. Genital index high; viewed laterally, median lobe very straight, basal bulb very broad, basal plate absent, apex produced, tapered to a small rounded terminal enlargement; viewed sagittally, median lobe tapering from the enlarged basal bulb to the acute apex; only 1 copulatory piece present; setae 4, very strong.

In the watershed of the Kentucky River, Ky.

Pseudanophthalmus horni Garman 1892

Length 4–4.2 mm. Antennal index .64; segmental index 1.0. Setal index .6. Genital index .20. Reid's cave, Lexington, Ky. (Plate 23, Fig. 4).

A distinctly aberrant type but related to *group menetriesi*.

GROUP INTERMEDIUS

Size large (not under 5 mm.). Highly convex forms. Appendages very long. Labrum transverse, with strong median lobe. Antenna exceptionally long, the 2nd segment 7 tenths the length of the 3rd. Humeri much effaced; setae normally grouped; striae evident, feebly punctate, apical groove strong, crescentic. Genital index abnormally high; viewed laterally, the median lobe very long, slender, arcuate above, quite straight below, basal bulb not large, basal plate hypertrophied, basal flexure not strong, apex slender, produced, abruptly inclined upward; viewed sagittally, median lobe straight, slender, constricting into a long digit-like process apically; copulatory pieces in the form of the usual spatula and style; internal sac armed with many rows of small barbs, pointing proximally; lateral lobes long, bearing 5 long, strong setae.

Caves on the Elk River, a tributary of the Tennessee.

Pseudanophthalmus intermedius Valentine 1932

(Syn. *Neaphaenops intermedius* Valentine 1931)[4]

Length 5–6 mm. Antennal index .78; segmental index .7. Setal index .6. Genital index .25 (Plate 23, Figs. 5, 5a).

[4] Jour. Elisha Mitchell Sc. Soc. **46**: 249. 1931.

Wonder and Crystal Caves, Monteagle, Tenn. (in the Elk River drainage, a tributary of the Tennessee). Found running over damp decaying boards and on the relatively dry floor of stalactitic passages.

Those from Crystal Cave possess relatively more oval elytra and will probably be described as a separate race when genital dissections can be made.

The remarkable parallelism existing between this aberrant cursorial species and *Neaphaenops tellkampfi* Er. of the Mammoth Cave complex was responsible for the error of placing the two in the same genus. Genital dissections, however, have revealed no immediate relationship. The extremely elongate penis of *P intermedius* contrasts strongly with the robust, elevated organ of *N. tellkampfi;* the latter was probably derived from the *menetriesi* type while the former is of independent origin, slightly reminiscent of the *robustus* type. Perhaps connecting links will yet be found in central Tennessee and the affinities of *intermedius* better understood. It might, at present, be placed in a separate genus based upon its penial equipment.

Characters which firmly unite it with the genus *Anophthalmus* are the following: frontal sutures, although feebly indicated posteriorly and thus approaching the aphenopsoid type, are complete; supraorbital setae 2 on either side; terminal and subterminal segments of maxillary palp subequal, the latter glabrous; elytral striae indicated, the apical groove well marked; the humeral group of setigerous papillae well removed from the elytral margin. From *group grandis, intermedius* may readily be separated by the subequal segments of its labial palpi.

The characters of the genus *Neaphaenops* Jeannel are now those of *N. tellkampfi* which Jeannel has indicated.[5]

Summary: the foregoing groups can be roughly classified into the following series which will better indicate their interrelationships.

Series A: penis of average size; median lobe arciform, slender; basal bulb not produced; apex produced, upturned. Inhabiting the region of the divide between the Potomac, the New and the Roanoke Rivers, Va., and W. Va.

Group hubbardi
Group grandis
Group fuscus
Group pusio

[5] R. Jeannel—Révision des Tréchinæ de l'Amerique du Nord; Archives de Zoölogie Experimentale **71**: 403–499. 1931.

Series B: penis small; median lobe simple, arcuate; basal bulb not produced; apex not produced. The divide between New and Tennessee river systems, Va. and W. Va.

Group higginbothami
Group hirsutus

Series C: penis small; median lobe angulate, elevated; basal bulb produced; apex produced downwardly. The Tennessee River drainage, Tenn., Ala.

Group engelhardti
Group alabamae

Series D: penis rather small; median lobe elevated; basal lobe produced; apex produced along the principal axis. The Ohio River drainage.

Group menetriesi
Group eremita
Group horni

Series E: penis large; median lobe slender, gently arcuate; basal lobe not produced; apex produced into a slender digit-like process. The divide between Cumberland and Tennessee River systems.

Group robustus
Group intermedius

CONCLUSIONS

1) In the face of extreme variation in outward appearance, as illustrated in *P. grandis* and *P fuscus*, some constant characters must be sought upon which to rely in the separation of species; the male genitalia have been found to be admirably suited to fulfill this requirement in anophthalmids.

2) Inasmuch as genital type can be correlated with river drainage systems, it is reasonable to suppose that anophthalmid distribution is conducted along river valleys, perhaps in part by subterranean streams.

3) Even in the case of large rivers, closely related forms may appear on both sides; rivers must therefore be looked upon as vehicles of anophthalmid distribution rather than as barriers. It is possible that subfluviatile cavernous connections fulfill this function.

4) Mountains, unless they are richly cavernous, act as an effective impasse to distribution.

5) The existence of closely related species in the same cave is a phenomenon frequently met with. Since these are usually in ecological association, it is probable that they evolved together under precisely the same environmental conditions, a fact which might be interpreted as evidence that segregation, other than physiological and psychological, is not necessary in the process of speciation.

6) Striking parallelism which often obscures true relationship, is very common among anophthalmids and may be interpreted as true orthogenesis.

PLATE 18

Fig. 1. *Pseudanophthalmus potomaca* Valentine sp. nov.; male.
Fig. 2. Male genitalia of same.
Fig. 3. *Pseudanophthalmus potomaca senecae* Valentine subsp. nov.; male genitalia.
Fig. 4. Pronotum of same.
Fig. 5. *Pseudanophthalmus pusio* Horn; pronotum.
Fig. 6. *Pseudanophthalmus pusio bathycola* Valentine subsp. nov.; pronotum.
Fig. 7. *Pseudanophthalmus hubbardi* Barber; male genitalia.

PLATE 19

Fig. 1. *Pseudanophthalmus hypertrichosis* Valentine sp. nov.; male genitalia.
Fig. 2. Same; male.
Fig. 3. *Pseudanophthalmus gracilis* Valentine sp. nov.; male genitalia.

PLATE 20

Fig. 1. *Pseudanophthalmus grandis elevatus* Valentine subsp. nov.; male genitalia.
Fig. 2. *Pseudanophthalmus grandis* Valentine sp. nov.; male genitalia.
Fig. 3. *Pseudanophthalmus fuscus constrictus* Valentine subsp. nov.; male genitalia.
Fig. 4. *Pseudanophthalmus fuscus* Valentine; male genitalia.
Fig. 5. *Pseudanophthalmus punctatus* Valentine; male genitalia.
Fig. 6. *Pseudanophthalmus pusio bathycola* Valentine subsp. nov.; male genitalia.

PLATE 21

Fig. 1. *Pseudanophthalmus alabamae* Valentine sp. nov.; male genitalia.
Fig. 2. Same; male.
Fig. 3. *Pseudanophthalmus intermedius* Valentine; head of male, dorsal surface.
Fig. 4. *Pseudanophthalmus hirsutus delicatus* Valentine subsp. nov.; male.
Fig. 5. Same; male genitalia.
Fig. 6. *Pseudanophthalmus hirsutus* Valentine; male genitalia.
Fig. 7. *Pseudanophthalmus digitus* Valentine sp. nov.; female.
Fig. 8. *Pseudanophthalmus higginbothami* Valentine; male genitalia.

PLATE 22

Fig. 1. *Pseudanophthalmus rotundatus* Valentine sp. nov.; male.
Fig. 2. Same; male genitalia.
Fig. 3. *Pseudanophthalmus engelhardti* Barber; male genitalia.
Fig. 4. *Pseudanophthalmus lodingi* Valentine; male genitalia.
Fig. 5. *Pseudanophthalmus humeralis brevis* Valentine subsp. nov.; male genitalia.
Fig. 6. *Pseudanophthalmus humeralis* Valentine; male genitalia.
Fig. 7. Same; pronotum.
Fig. 8. *Pseudanophthalmus humeralis brevis* Valentine subsp. nov.; pronotum.
Fig. 9. *Pseudanophthalmus fulleri* Valentine sp. nov.; female.

PLATE 23

Fig. 1. *Pseudanophthalmus robustus* Valentine; male genitalia.
Fig. 2. *Pseudanophthalmus eremita barberi* Jeannel; male genitalia.
Fig. 3. *Pseudanophthalmus menetriesi* Mots.; male genitalia.
Fig. 4. *Pseudanophthalmus horni* Garman; male genitalia.
Fig. 5. *Pseudanophthalmus intermedius* Valentine; male genitalia.
Fig. 5a. Same; copulatory pieces and internal sac.

PLATE 24

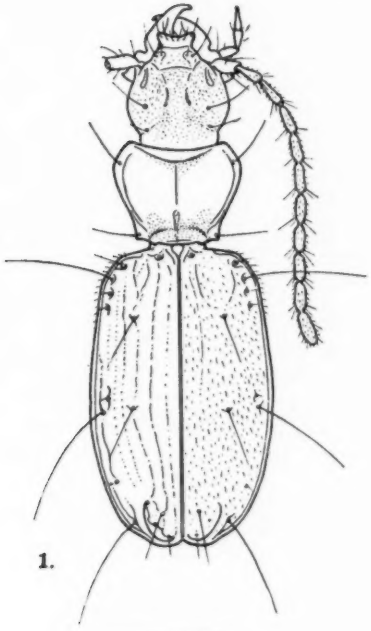
Figs. 1–4. Types of *Pseudanophthalmus grandis* and the corresponding male genitalia.

PLATE 25

Fig. 1. A series of pronota of *Pseudanophthalmus fuscus* illustrating transitional variation.
Fig. 1a. Male genitalia of typical *P. fuscus*.
Fig. 1b. Male genitalia of *P. subaequalis* (syn. *P. fuscus*).
Fig. 2. A series of pronota of *Pseudanophthalmus grandis* illustrating transitional variation.

DEPARTMENT OF ZOOLOGY,
UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

PLATE 18



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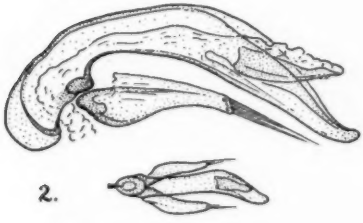

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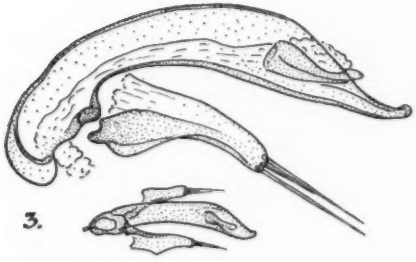

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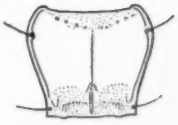

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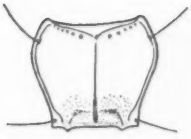

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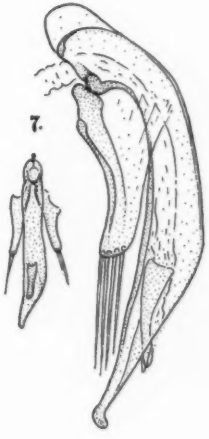

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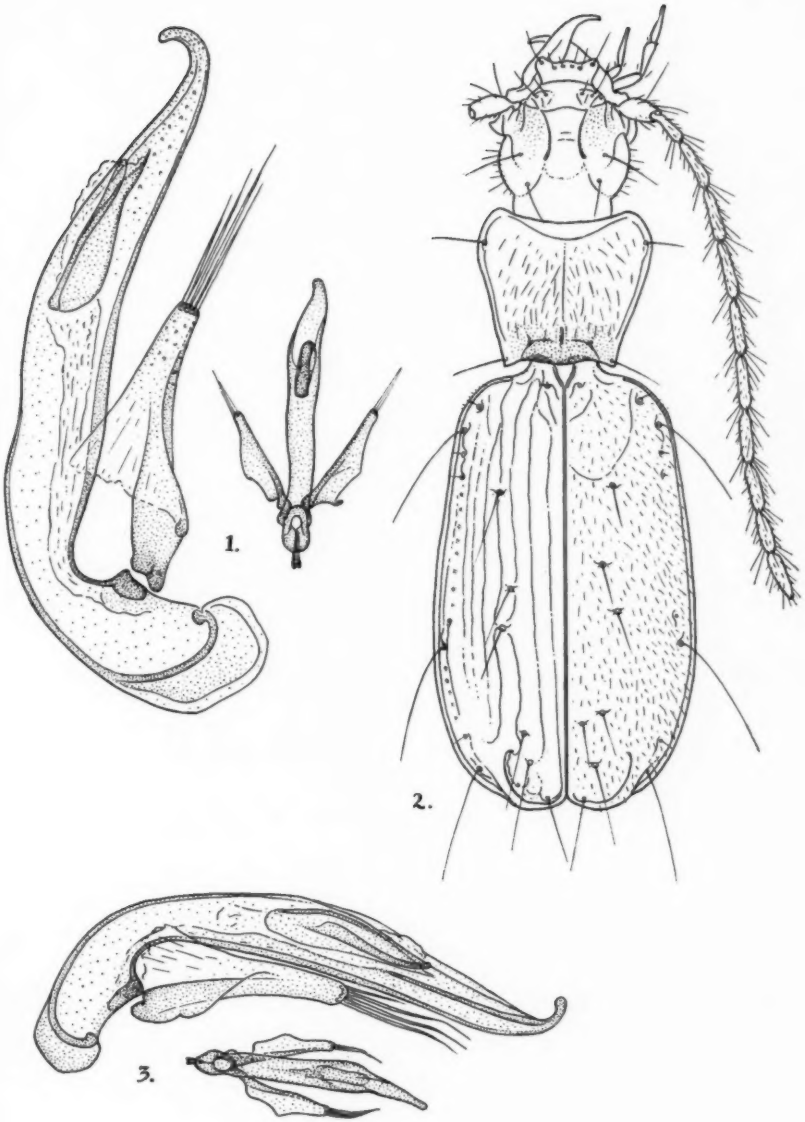
PLATE 19



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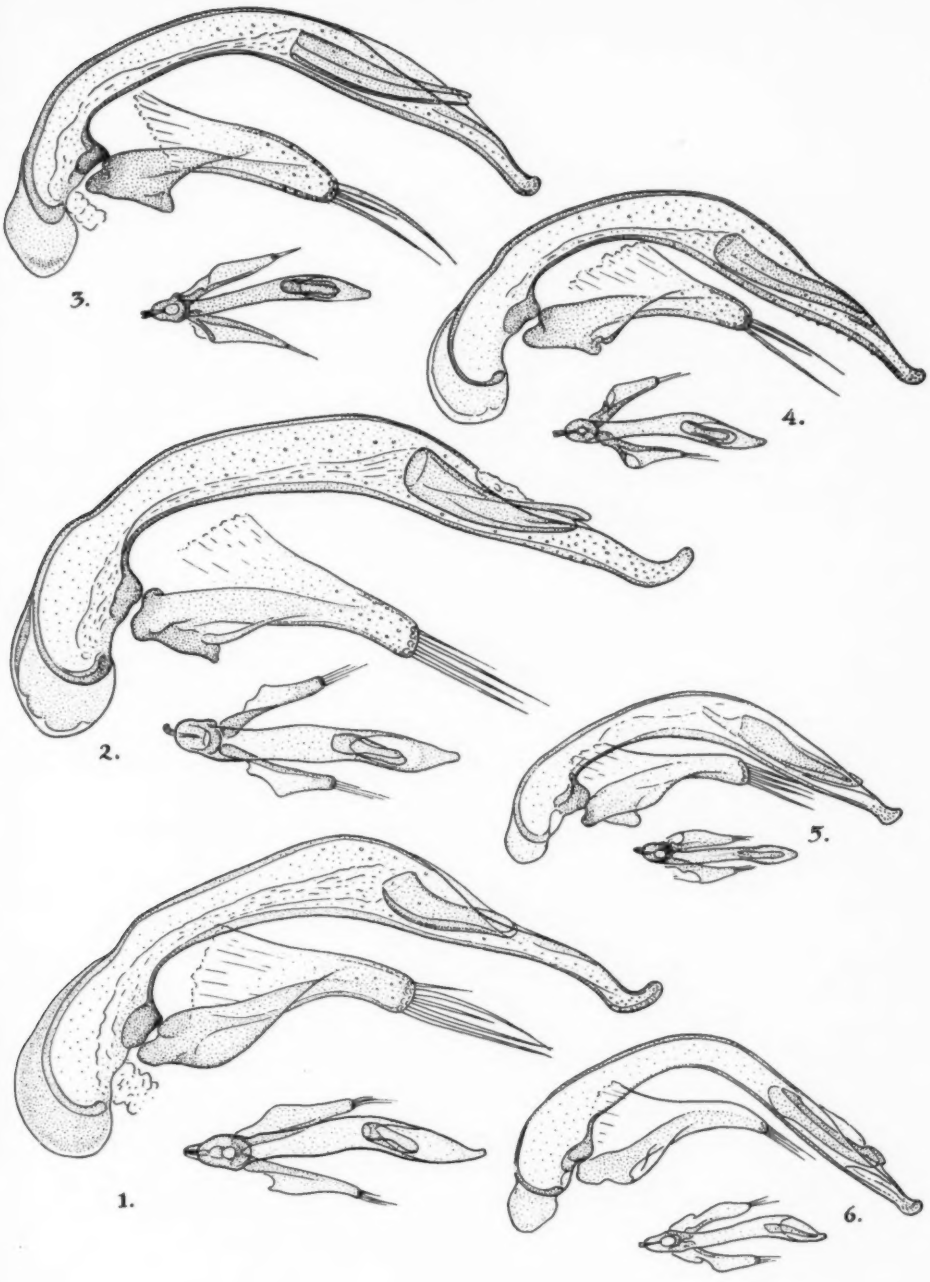

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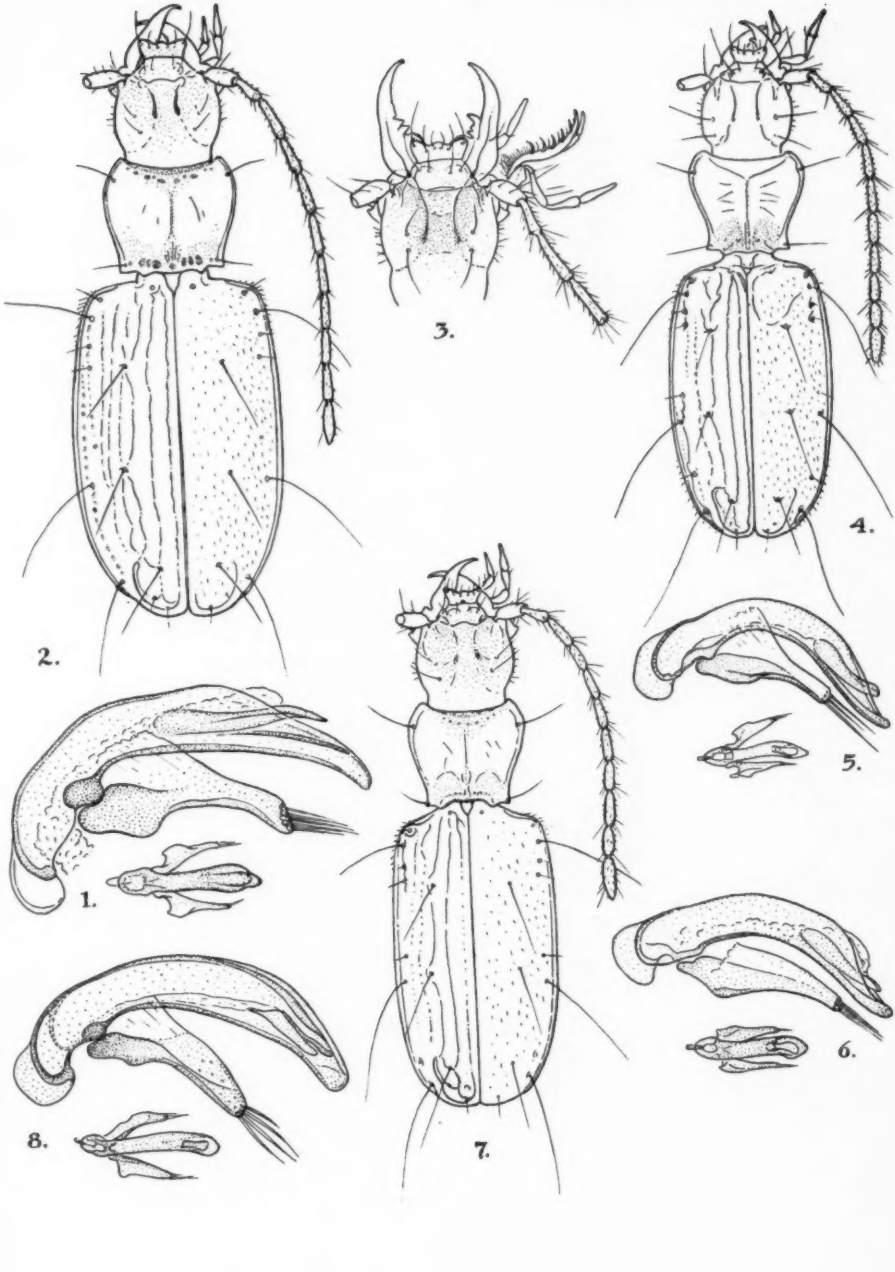

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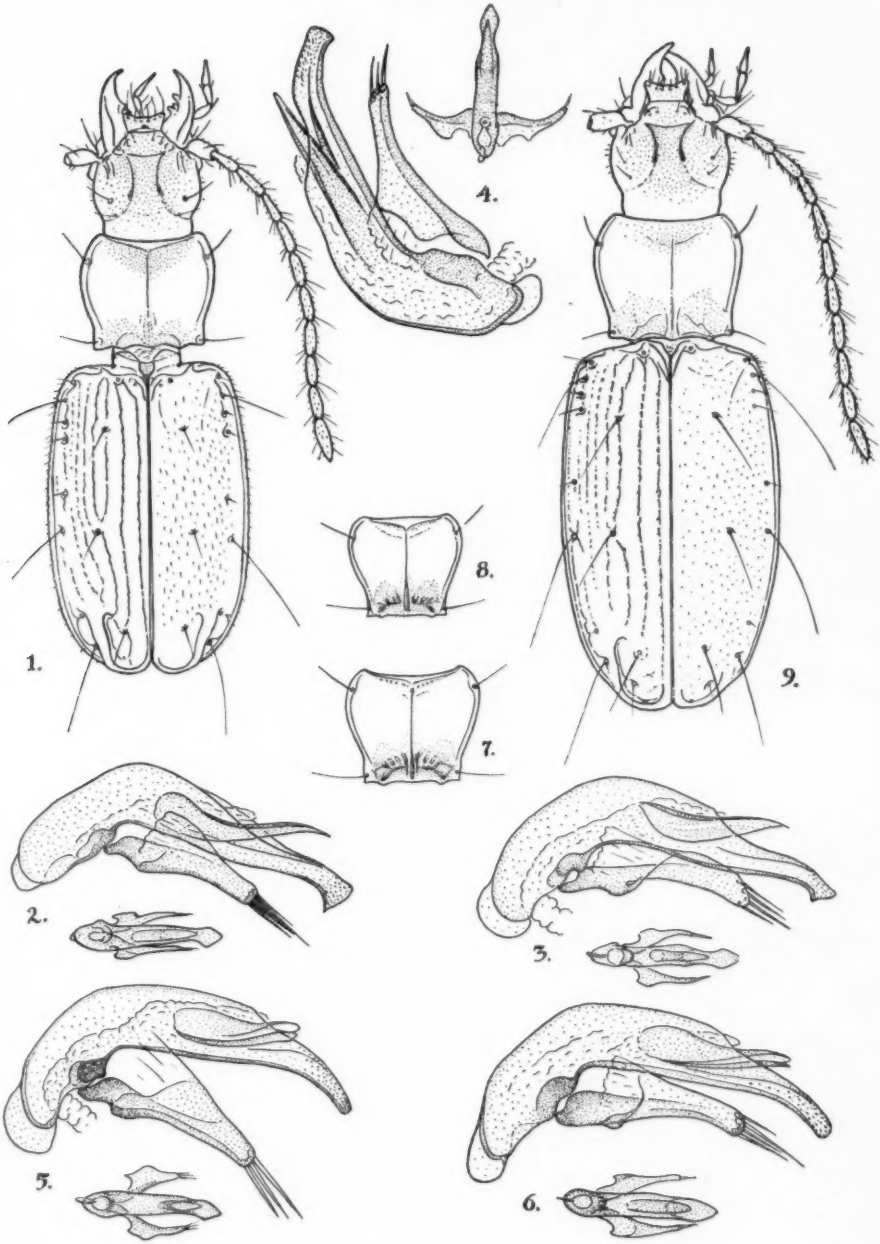


PLATE 23

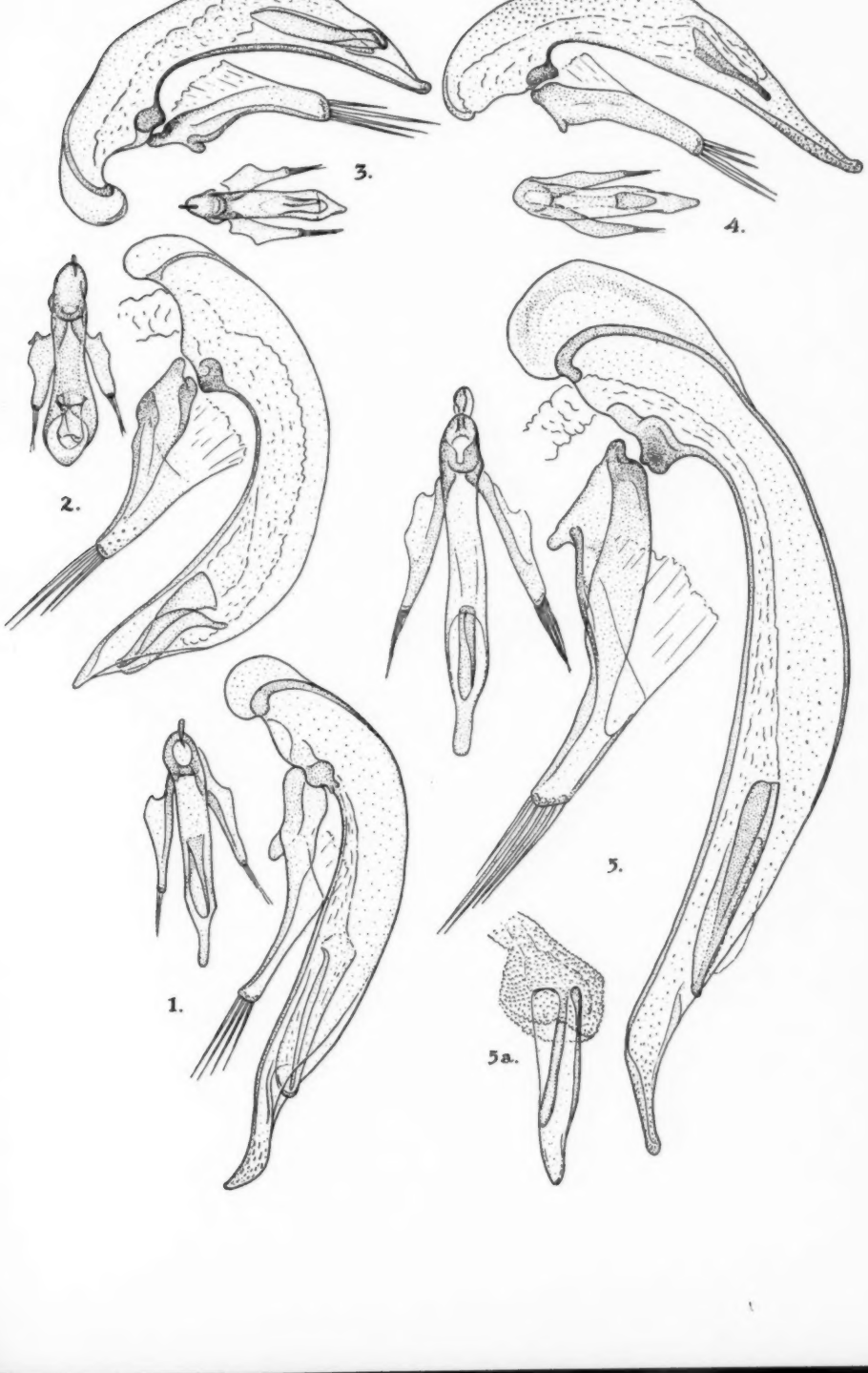


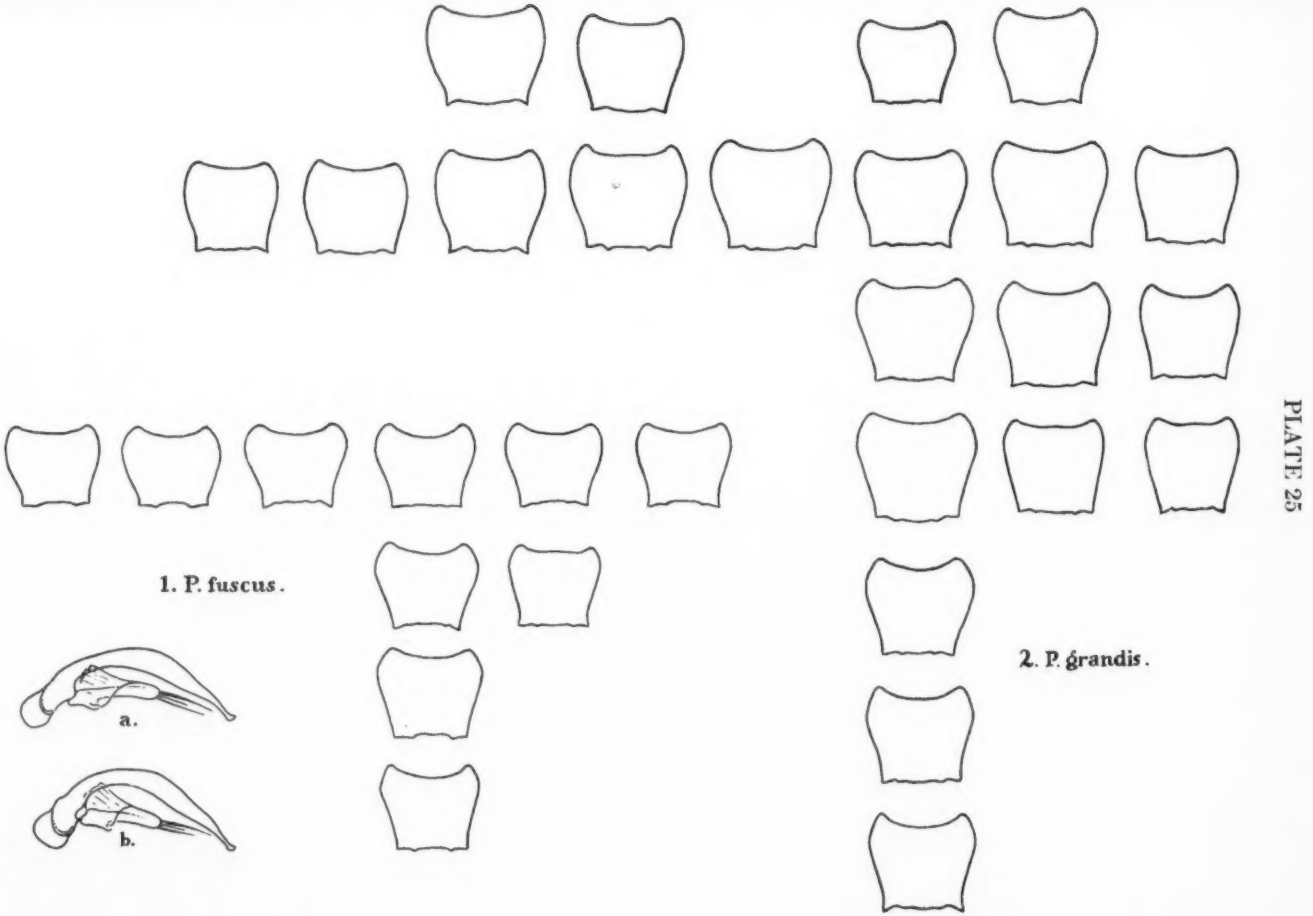
PLATE 24

Type 1.

Type 2.

Type 3.

Type 4



1. P. fuscus.

2. P. grandis.

CYTOLOGICAL OBSERVATIONS ON ZOOSPORE FORMATION IN LEPTOLEGNIA CAUDATA DE BARY

By A. C. Mathews

Plates 26 and 27

It has generally been accepted that the cilia of the zoospores of the water fungi are formed as outgrowths from some definite point. In 1924 Couch presented observations on *Leptolegnia caudata* de Bary to show that the cilia are formed in that species from the delicate protoplasmic strands which connect the spore initials. Cotner (1930, b), working with many other species of water-moulds, found that "the cilia develop as outgrowths from the region of a basal granule (blepharoplast) which has reached a position near the plasma membrane as a result of nuclear activity." Other investigators have also reported that the cilia of zoospores of other plants arise as outgrowths from the region of blepharoplasts. Since Couch's results were so unusual, it seemed desirable to reinvestigate the problem of the origin of the cilia in *L. caudata* and especially to determine: (1) If the cilia are derived from the connecting threads (Couch, 1924); or (2) if the cilia grow out from the region of blepharoplasts (Cotner, 1930, b), and finally fuse with these connecting threads; or (3) if the cilia develop entirely independently of these connecting threads.

Methods

The fungus was collected near Chapel Hill, N. C., by A. B. Couch during the summer of 1931. Cultures were made by the transferring of a few cut hyphae to hemp seed halves in distilled water in sterile Petri dishes. The distilled water was previously filtered through animal charcoal, since the water so treated seemed to favor the formation of sporangia. The cultures were prepared 4 to 5 days before the material was to be used. When the plants were almost mature (i. e. about 1½ to 2 cm. long), the water in which they were growing was changed once about 7 hours and again about 2 hours prior to killing and preparing the material for study. Ordinarily this procedure provided an abundance of sporangia in all stages of development.

Excellent opportunity for study on living material was afforded by preparing the usual sterile water mounts and also by hanging-drop

mounts, taking care that all the apparatus was thoroughly clean. The transfer of the cut sporangia was made with a section lifter. The observations were made under the oil immersion objective.

It was found necessary to use a variety of methods for the fixing and staining of the material. Cotner's (1930, a) method of killing by exposure to 1 per cent osmic acid fumes for the shorter lengths of time, i. e. 5–10 seconds, and finally staining with gentian violet or crystal violet, etc., as he describes, was considerably used. This method was found quite suitable for the grosser details of the spores and their cilia while still within the sporangia, and excellent for the details of the discharged zoospores, but it was not found entirely adequate for all cytological details. It is a noteworthy point that this technique did not afford a clear differentiation of the details of the nuclei of the vegetative hyphae, even in the small number of cases in which the nuclei showed up at all. Fixing the material in potassium iodide and mounting it in 10 per cent aqueous glycerine solution were found very suitable in preparing the material for a study of the more general morphological details. Bouin's fluid,[1] chrome-acetic solution (for marine algae)[1] and the special chrome-acetic-osmic solution,[1] without the osmic acid, gave about equally satisfactory results as killing and fixing fluids. The stains used with these latter fixing fluids were: a modification of the Gram's method[2] and Haidenhain's iron-alum haematoxylin. These latter

[1] Chamberlain, C. J.: *Methods in Plant Histology*, fourth revised edition.

[2] Schedule for the modification of Gram's staining technique: After thorough dehydration of the material in alcohol and clearing in xylol, it was brought back down to water, etc., as follows:

a. Water, 2 minutes.
b. 1 per cent aniline solution of gentian violet, 10 minutes and longer. (To make aniline solution of gentian violet: 2 cc. aniline oil plus 18 cc. of 95 per cent alcohol. When thoroughly mixed, add enough water to make total 100 cc. Now add 1 gm. gentian violet.)
c. Water, about 5 seconds (just long enough to wash off the superfluous stain).
d. Iodine solution, about 1 minute (iodine, 1 gm.; potassium iodide, 2 gms.; water, 300 cc.). This solution should be kept in a dark place.
e. Water, about 5 seconds.
f. 95 per cent alcohol, about 12 seconds. (The gentian violet is very soluble in alcohol.)
g. Absolute alcohol, about 6 seconds.
h. Clove oil, 1 minute. (Gentian violet is also soluble in clove oil, but the stain dissolves more readily from the cytoplasm than from the nucleus.)
i. Cedar oil, 1 minute. (Stops action of clove oil.)
j. Xylol, 3–5 minutes.
k. Mount in balsam.

methods were best for bringing out the cytological details of the spores, while they were still within the sporangia. For the differentiation of the nuclear details, this modification of Gram's method of staining, after the fixation in Bouin's fluid, dehydration in alcohol, and a very brief period of clearing in xylol, gave the best results.

OBSERVATIONS ON LIVING MATERIAL

The early stages of spore formation were described by Couch (1924) who showed that the phenomena involved do not markedly differ from the corresponding phenomena generally accepted for *Saprolegnia* and *Achlya*. Passing over these, a stage in the late individualization of the spores is taken for the starting point in the present discussion. This stage is one just after Couch's fig. 3 (see figs. 3–6 of this paper). The typical condition is the arrangement of the spore initials end to end in single file, each initial being quite irregular in outline, somewhat spindle-shaped and separated from each of its neighbors by a comparatively thick protoplasmic connection, through which strongly refracting granules can be seen moving to and fro. These protoplasmic connections are gradually thinned down; meanwhile the spore initials are in a constant amoeboid and gentle, rocking motion. At this stage the two cilia are quite evident, appearing as short, somewhat bristle-like outgrowths from a common depression at about the mid-point of one side of the spore initial (see figs. 3, 5 and 6). According to Cotner (1930, a), Rothert (1892) described the cilia in *Saprolegnia* as appearing at first as "slow outgrowths like little short, straight bristles which show faint oscillations." Typically, in *L. caudata*, one of the cilia is directed forward and the other backward in the sporangium. It may be noted here that in the later development of the spores in the sporangium, certain ones on which both of the cilia are directed either forward or backward may be seen quite frequently. Throughout the entire development of the cilia they appear to maintain approximately an equal length, and each of them shows a very distinct and characteristically spiral movement from its point of insertion. This spiral motion is in a clockwise direction (or counter-clockwise under the compound microscope).

The thinning down of the protoplasmic connections between the spore initials continues rapidly and is accompanied by a rapid elongation of the cilia and the smoothing down of the spore surfaces. The gentle, rocking movement of the spores seems to be somewhat increased by the active and elongating cilia. In some cases this rocking movement

seems to exert stress on the very thin protoplasmic connections between the spore initials, while in others the amount of stress, if any, is very small. At this point, and even earlier, a large central vacuolar structure is very conspicuous in the spore initials. This is evidently the nucleus (see fig. 7). The nucleus seems to contain a dense body approximately at its center. This is recognized as the central body of the nucleus and is described later in the paper.

The developmental processes mentioned above continue with all efforts apparently directed toward the final separation and individualization of the spores and the formation of them into rod-shaped individuals, which are long and slender in case they are contained within a sporangium of small diameter or short and thick in case the sporangium is of greater diameter. It seems that in most cases the connections are thinned down past the point of perceptibility (see fig. 8), so that finally, when the spores have assumed their definite rod-shape just prior to the "swelling" stage (to be described later), they no longer exist. The actual breaking of the connections is probably helped in many cases by the rocking movement of the spores (see fig. 7). In some cases of this condition the connections seemed to persist up to the swelling stage of the spores and were broken very early during this stage, the breaking probably being helped by the swelling phenomenon. The growth and maturation of the cilia are very rapid. In most cases they have apparently reached their maximum length just after the spores have become completely rounded at their ends.

From the observations on living material the writer regards the evidence based on the two following points as quite conclusive that the protoplasmic connections play no part in cilia formation: (1) Oil immersion observations in great numbers show the breaking of all connections between the spores, and the complete rounding off of the ends of the spores before the discharge; (2) in the progress of the spore-discharge from a branched sporangium (which is quite a common condition) (see fig. 1), all the spores of all the branches as well as those of the main sporangial hypha emerge through a common terminal rupture (Coker, 1909), which may be in the main sporangial hypha or a lateral branch. Using the latter case for the example, the spores moving from the proximal and distal ends of the main sporangial hypha immediately into the lateral branch approximate a very close alternation of entrance in single file into the branch. Under such circumstances, it would be practically impossible for any protoplasmic connection so slight as to be invisible under the oil immersion magnification to remain intact

until the spores which it connects are discharged. Rothert (1903), in his description of the spore development in *Aphanomyces* sp., believes that the protoplasmic connections persist, even where they are invisible, and he assigns importance to this condition in the spore-discharge. Jones and Drechsler (1925) describe the alternating egression of the spores in the sporangia of *Aphanomyces euteiches*, but in a somewhat reversed manner than I find in *L. caudata*. They say, "The entire process, with its reversals in direction resulting in the discharge of successive zoospores through separate evacuation branches, failed to suggest any considerable effectiveness of visible and possibly invisible connecting strands in determining the course of any individual zoospore."

As the last vestiges of the broken connections on the spores are being withdrawn, the spores begin a rapid swelling (Couch, 1924). This condition seems to be brought about by the sudden enlargement of vacuoles which are present in the peripheral cytoplasm of the spores. Usually, this swelling causes the ends of one spore to be brought into close contact with the proximal ends of its two neighbors (see figs. 8–10). I have applied the term, bucking, to this condition and will hereafter refer to it by this term. The large nucleus is now obscured by these large peripheral vacuoles in the spore cytoplasm.

Although this bucking of the spores end to end seems to be the typical condition, it does not always occur. Sometimes in a sporangium which contains a relatively small number of spore initials, the swelling of the spores finally occurs as usual, but many of them remain widely separated. However, in spite of the lack of immediate contacts between these spores as well as between the distal spore and the tip of the sporangial wall, this type of sporangium discharges its spores in the usual manner.

There were sometimes observed, under oil immersion magnification, branched, discharging sporangia, in which abrupt bends (here and there) greatly slowed up the progress of the spores inside the sporangium. As these spores were being apparently forced slowly through the constrictions in the sporangium, it was possible by gentle pressure in the focus, to observe a slowed-up spore being forced very slightly to and fro in response to the pressure, and at the same time a corresponding equal and counter-balancing reaction by the neighboring spores. Although these spores were actually separated by distances equal their lengths and greater, the general effect under these circumstances was practically the same as if there had been direct contact between them. It seems quite evident from this condition and that described in the pre-

ceding paragraph, that there is present in the sporangium a transparent, intersporal fluid which is very important in the spore discharge. The presence of such a substance was the opinion of de Bary (1887, p. 82). It is discussed and advocated by Coker (1923, pp. 2 and 3), but the efforts of Totten (see Coker, l. c.) to demonstrate this substance in *Achlya* by selective stains and other means were unsuccessful. I have noticed, however, a faint staining of the regions between the spores of nearly mature sporangia of *L. caudata* by the gentian violet used in the Cotner technique.

While the spores are in the distended condition characteristic of the bucking stage, a terminal rupture occurs in the main sporangial hypha or branch of this hypha, and the spores are discharged. In the discharge, the first spores to emerge from a sporangium are shot out with great momentum (Couch, 1924), and the distances between these while in the sporangium are, of course, very small; the last spores are discharged very feebly and the distances between them are much greater.

Contrary to Couch's (1924) observations, no threads which formerly connected the spores, either broken or unbroken, were observed on any of the discharged zoospores. None of the linking of the spores by their cilia in the spore discharge, described by Petersen (1910, p. 522) for *L. caudata*, was observed. As described by Coker (1909), the zoospores "in nearly all cases emerge from the sporangium much drawn out, as long, more or less cylindrical rods, with the cilia attached to the center on one side (see figs. 11–13). As soon as they escape, the two ends of the rod begin to fold backward, away from the cilia, and fuse as they go, until by complete fusion they lose their identity and form a pear-shaped spore with the cilia near the tip, and the long axis at right angles to the original rod" (see figs. 12–15). Immediately after the zoospore is discharged and has bent into a very slight v-shape (see figs. 12, 13), it begins a tumbling and somewhat rotary motion. This type of motion persists until the zoospore assumes its "pip-shape" (see figs. 14, 15), whereupon it swims away in an irregularly spiral course through the water.

The time necessary for the entire sequence of events from the earliest stage of development of the sporangiospore described here to that of the mature pip-shaped zoospore is approximately 10 minutes.

OBSERVATIONS ON STAINED PREPARATIONS

The details of the development of the spores from the early spore initial stage to the spore discharge were best shown by the Bouin's

fixation followed by dehydration in alcohol, a very short period of clearing in xylol and finally staining by the modification of Gram's staining method. The other stains showed the same details, but with less clarity.

Smith (1923) describes the nuclei of the vegetative mycelium of *Saprolegnia* to be "neither uniform in shape nor size, but that there is a gradual transition in shape from a spherical form in the zoosporangium to a long torpedo-like form in the lower parts of the thallus." Cotner (1930, b) describes the nucleus in the spore initials of *Achlya conspicua* to be a "crescent-shaped spindle," with "the bulk of chromatic material" at a "position mid-way between the poles" and one or more granules at each pole. The nuclei in the young spore initials of *L. caudata* are quite large and varied in shape. The shape varies from spherical to an elongated, somewhat spindle-like condition. There is close agreement in the size and shape of these nuclei with those in the vegetative hyphae (figs. 2–6).

The general nuclear structure in *L. caudata* agrees with that which is commonly accepted for the water fungi (see Smith, 1923, and Couch, 1924). It consists of the nuclear membrane, a large central body and peripheral chromatic masses. Fine linin threads connect these peripheral chromatic masses with the central body. Generally, the central body has a clear region surrounding it. Light staining with the Gram's stain seems to show this body to be fluid within, with a more deeply staining outer coat, as was also observed by Smith (1923). In the nuclei of the vegetative hyphae the central body is somewhat spherical (fig. 2), but in those of the young ciliated spore initials it has assumed in its lateral aspect a more or less top-shape (figs. 3, 5, 6). In this top-shaped condition the central body shows a large chromatic structure at its broad, distal end and a much smaller chromatic body at its tip. These two chromatic structures are separated by a nearly clear zone (figs. 3, 5, 6). This condition is not as marked in the spore initial as it is later in the development of the spore, e.g., after the breaking of the protoplasmic connections (figs. 8–11).

The writer prefers to regard the dense chromatic body at the tip of the top-shaped central body as a centrosome (see Chamberlain, 1903). This centrosome is generally in rather close contact with the nuclear membrane. The nuclear membrane seems to have been pushed noticeably outward by the beak-like process, especially in the case of the spindle-shaped nucleus, as this process grew out from the originally spherical central body (figs. 9, 10). Before the swelling stage of the

spore, the centrosome and that part of the nuclear membrane nearest it are in turn rather closely located to the plasma membrane of the lateral depression, from the bottom of which the cilia are seen to project.

In the young spore initial the peripheral cytoplasm is rather finely granular and somewhat delicately reticulate (figs 4–6). Iron-alum haematoxylin stains very clearly the abundance of coarse granules which are so conspicuously moving to and fro in the protoplasmic connections between the living spore initials at this stage (fig. 5). These coarse granules remain a characteristic constituent of the cytoplasm of the spore even until its maturity (figs. 11–15).

As regards the origin and development of the cilia in the oomycetous zoospores, especially in the second swimming stage of species of *Achlya*, *Aphanomyces*, and *Saprolegnia*, Cotner (1930, b) states that both poles of the crescent-shaped nucleus, "with their attached or included granules [blepharoplasts], approach very near to or actually touch the plasma membrane, they may then withdraw from the membrane leaving there one or more granules. At points near these granules we find cilia appearing as pseudopod-like projections, which later are matured into active cilia." The essentials of the corresponding phenomena in *L. caudata* seem to disagree with those of this description. There appears to be no evidence of the bending of nuclear poles around to deposit basal granules in *L. caudata*; nor is there evidence that the cilia first appear as pseudopod-like projections. The earliest and shortest cilia are observed at a very early stage of the spore initials. They appear as bristle-like outgrowths through the plasma membrane of the median lateral depression (figs. 3, 5, 6). These cilia apparently have direct connections with the centrosome and appear as if they might be simple outgrowths from it. They are of practically the same diameter at this stage as they are at maturity (figs. 11–14). Although the staining is usually so light as not to show cilia in all the possible cases, the other cytological conditions are such as to make it practically certain that they are present on all normal spore initials, after the spore initials have noticeably begun the thinning down of their protoplasmic connections. These observations are, of course, also contrary to those of Couch (1924), in which he considers the cilia as formed from the protoplasmic connections.

When only slight vestiges of the broken intersporal connections remain to be withdrawn by the spores, the peripheral framework of the majority of the nuclei exhibits in its lateral aspect a distinct tent-shaped condensation effect about the top-shaped central body which is oriented in a plane perpendicular to the long axis of the spore (see fig. 9). In many

spores of this stage, however, the nucleus is still quite spherical (fig. 8). The former condition would seem to be characteristic of the originally spindle-shaped nucleus, and the latter characteristic of the originally spherical nucleus. A nucleus may have either of these two shapes or any of all the possible intermediate ones throughout the remainder of the development of the spore into its pip-shaped condition. In the iron-alum haematoxylin preparations the nuclear membrane and the peripheral chromatic granules are quite difficultly seen.

At the bucking stage, the originally lateral depression in the spore no longer exists, and the points at which the cilia are attached to the plasma membrane are clearly separated a short distance from the centrosome (fig. 10). These conditions are very probably brought about by the general swelling of the spore just prior to this stage.

The points of attachment of the cilia to the plasma membrane stain very clearly in Gram's staining preparations and were at first considered to be the blepharoplasts of Cotner (1930, a; 1930, b) (figs. 8–14). But I now regard the condensations of the stain at these points simply as collections of stain, and not definite granules. Sometimes longer collections of the stain are seen at the bases of the cilia, where these bases happen to be lying in close contact with the plasma membrane. These observations, together with others on spores in which blepharoplasts would ordinarily be expected to be seen but are absent, would seem to make somewhat doubtful the presence of definite blepharoplasts in the spores of *L. caudata* as Cotner describes them for several species of Oomycetes.

At this point (i. e. the bucking stage and just prior to the spore discharge), the typical spore is seen to be a smooth, rod-shaped structure, containing a rather large nucleus of the above description) at a lateral position about mid-way its length (figs. 10, 11). Direct continuations of the cilia from the centrosome through the cytoplasm, the plasma membrane, and outside the spore can frequently be seen. Evidently, the cilia are at their maximum length (fig. 11). The cytoplasm of the spore is quite vacuolate, in agreement with the living spore at this stage, and it contains numerous coarse and deeply staining granules. The spores, long since devoid of their connections, and characterized by the above details, are now ready to emerge. A very few faint suggestions of possible connections between the spores just prior to the discharge were shown by the Cotner technique, but these were regarded as abnormal, and certainly not typical.

The nucleus in the bent, rod-shaped zoospore just after the discharge

seems to have approached a bit nearer the side of the spore on which the cilia are attached (figs. 12, 13). The ends of the spindle-shaped nuclei are often directed almost opposite the ciliary insertions, while in the case of the originally spherically shaped nuclei, the side which is directed outward toward these insertions is simply a bit bulged or pulled in that direction. The two cilia are generally of equal length and directed laterally from the convex side of the bent rod (Coker, 1909; Petersen, 1910, p. 522). They are usually attached to a slight papilla which has appeared at their points of attachment to the plasma membrane.

The mature pip-shaped zoospore shows very little change over that of the bent, rod-shaped zoospore except that which could ordinarily be expected as resulting from the continued folding back of the ends of the rod away from the cilia (figs. 14, 15). The central portion of the zoospore cytoplasm is conspicuously vacuolate, while the parietal protoplasm is finely reticulate. The course, deeply staining granules are still evident.

SUMMARY

1. The two cilia of the spore of *Leptolegnia caudata* are first seen when the spindle-shaped spore initial is still connected to its two neighbors by quite thick protoplasmic strands. They appear as short, bristle-like outgrowths from a common depression at about the mid-point of one side of the spore initial, usually one being directed forward and the other backward in the sporangium.

2. The protoplasmic connections between the spores take no part in the origin and development of the cilia.

3. The diameter of the young cilia is approximately the same as that of the mature ones. There is no evidence that they are formed from pseudopod-like structures.

4. The maximum length of the cilia is reached by the time the broken protoplasmic connections have been completely withdrawn. The two cilia of any given spore are of approximately the same length.

5. The cilia are seen to be connected directly with a chromatic body [centrosome (?)] at the apex of the top-shaped central body in the nucleus.

6. Both of the cilia on the living spore inside the sporangium show movement with about an equal force in a spiral fashion and in a clockwise direction (or counter-clockwise under the compound microscope) from their points of insertion.

7. The general structure of the nucleus agrees with that which is commonly accepted for the water fungi. In the spore initial the spherical central body puts out a beak-like process which bears the centrosome at its summit. With this exception, the structure of the nuclei of the young vegetative hyphae agrees quite closely with that of the nuclei of the spores.

8. A few observations which suggest the presence of an intersporal substance, important in the spore discharge, were made.

This work was done at the suggestion and under the supervision of Dr. J. N. Couch, for whose helpful criticism and advice the writer wishes to express his gratitude. The writer also gratefully acknowledges his indebtedness to Dr. W. C. Coker and Miss Alma Holland for their helpful suggestions in the preparation of the manuscript.

UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

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EXPLANATION OF PLATES

Magnification is ×1440 unless otherwise specified.

Figs. 1, 4, 8 and 11 are from Bouin's fixation and Haedenhain's iron-alum haematoxylin staining preparations; figs. 3, 12, 13, 14 and 15 are from Cother's osmic acid killing and gentian violet staining preparations; fig. 7 is from a potassium iodide preparation; and figs. 2, 5, 6, 9 and 10 are from Bouin's fixation and the modification of Gram's staining preparations.

PLATE 26

Fig. 1. Nearly mature sporangium (semi-diagrammatic). ×52.

Fig. 2. Small portion of a young vegetative hypha, showing the nuclear and cytoplasmic details.

Figs. 3–6. Young spore initials, connected end to end by protoplasmic connections which are still quite thick. Differently shaped nuclei and young cilia on some of the initials are shown.

PLATE 27

Fig. 7. Potassium iodide preparation showing young spores just after the breaking of the protoplasmic connections between them. The connections of the two spores at the bottom of the figure were perhaps broken mechanically in fixing the preparation.

Fig. 8. Spores withdrawing their broken protoplasmic connections Their cilia are approaching their maximum length.

Fig. 9. Spores, after withdrawing their broken protoplasmic connections. The cilia have reached approximately their maximum length.

Fig. 10. Spores at about the "bucking" state. The staining is too light to show the cilia, but the points where they would normally be expected to be attached to the plasma membrane are clearly stained.

Fig. 11. Rod-shaped spores just before emerging from the sporangium, perhaps caught in the process of emerging. The details are shown for only one of the three spores.

Figs. 12 and 13. Bent rod-shaped zoospores, after emerging from the sporangium.

Figs. 14 and 15. Pip-shaped zoospores of the first swimming stage. The zoospore of fig. 15 is included (without its cilia) mainly because its nucleus is somewhat more typical than that of the zoospore of fig. 14.

PLATE 26

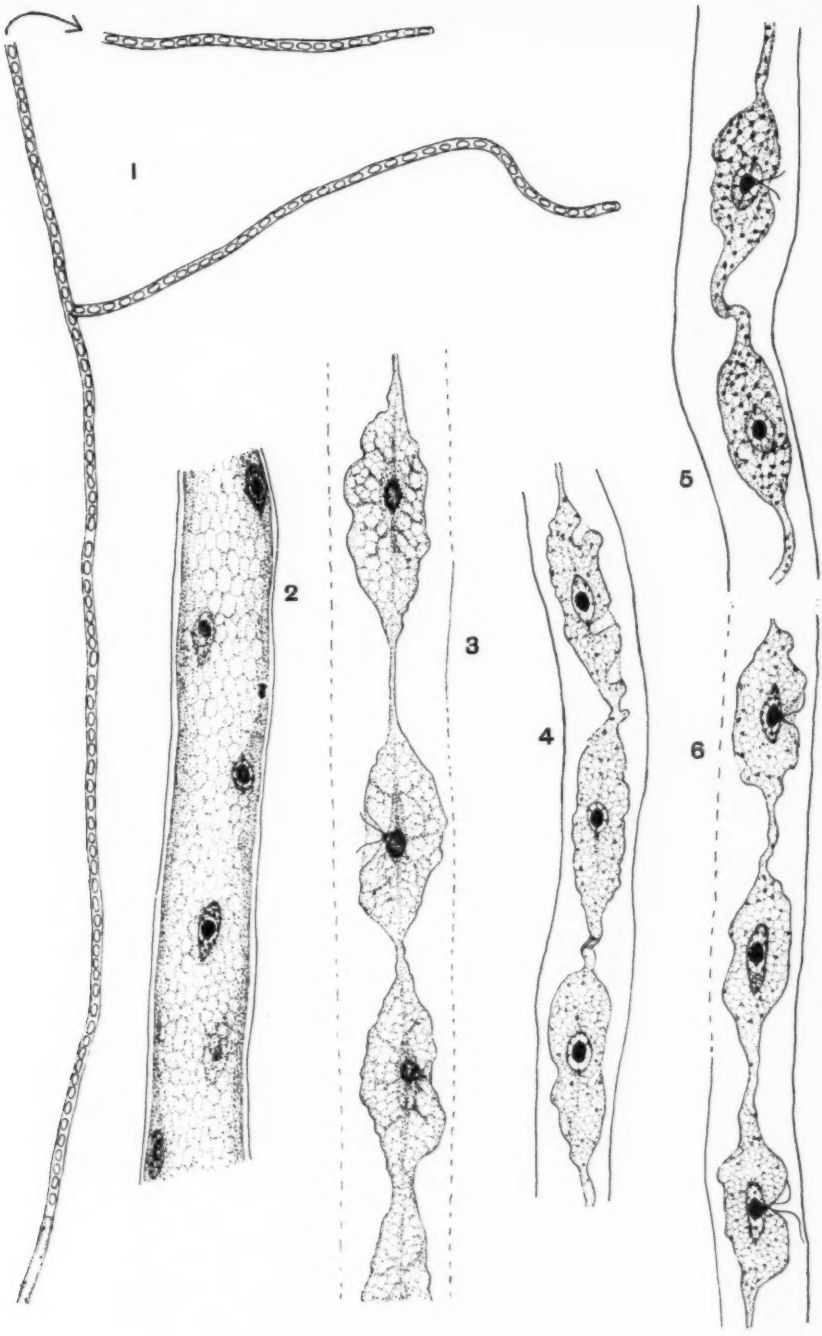
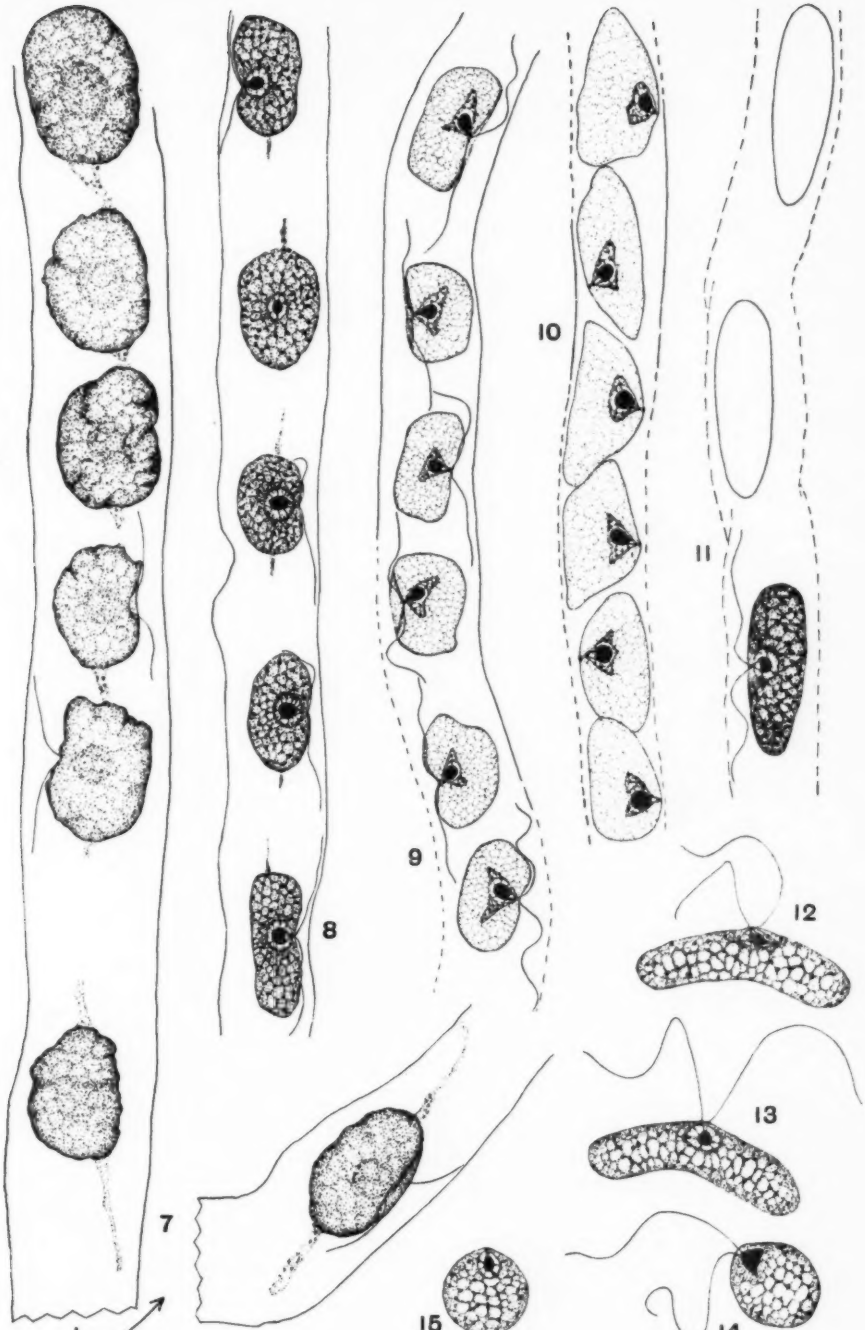


PLATE 27



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STUDIES ON THE GENUS PYTHIUM

By Velma Matthews

In this book an attempt is made to give descriptions of all the species of Pythium which had been discovered at the time of publication, and to report on twenty species which have been isolated by the writer. Of these, five are considered new. Keys are given to the genera of the family Pythiaceae and to the species of the genus Pythium. Several species are reported from the United States for the first time.

There are twenty-nine zinc line plates. Twenty-six of these are from original drawings and three are copies from illustrations of species which the writer has not seen. There are 134 pages in all, nineteen of which are devoted to a bibliography. 7″ x 10″. (Published August, 1931.) Postpaid, $3.00.

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